consulting engineer

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Progress at Niagara
Time Standards
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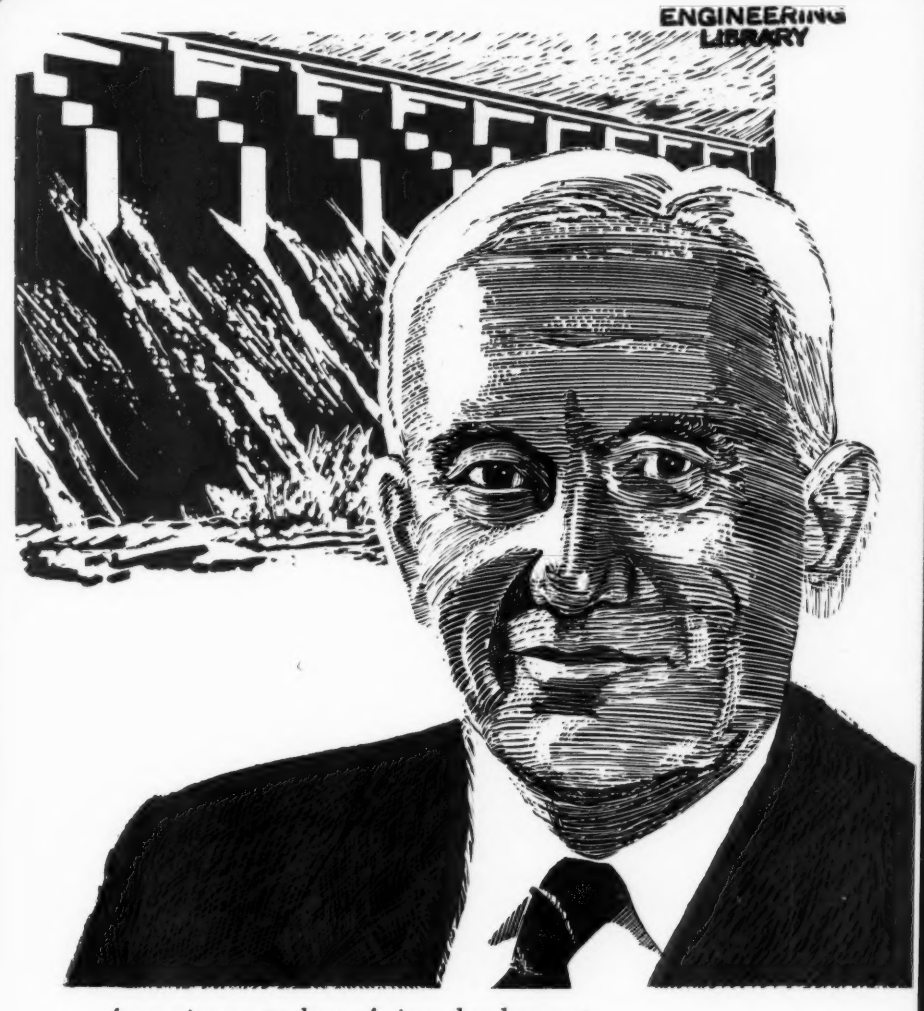
Lighting for Inspection
Explosives Are Versatile
Air Pollution Abatement



. . . from pioneer to dean of river development

Just Scratching the Surface

LEROY F. HARZA grew up in the Northwest in an era when hydroelectric and river control projects were of prime importance to the future development of the country. It was only natural that young Harza, showing talent and interest in engineering, should study and later specialize in this new

(Continued on page 6)

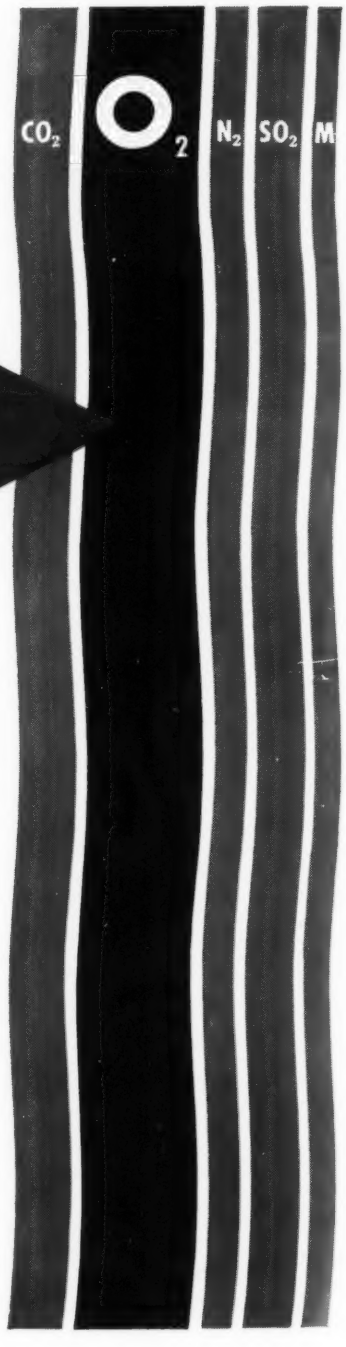
December 1953

The Consulting Engineer's Professional Magazine

HOW ACCURATELY DO YOU MEASURE

EXCESS AIR

IN YOUR FLUE GAS?



Prevent heat loss up the stack. Too much or too little excess air means big money in today's boiler plant. It's important to *know* and *control* excess air exactly—regardless of load or fuel changes.

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MICHIGAN CITY 32, INDIANA

VOLUME 2
NUMBER 10

consulting engineer

Published by
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DECEMBER 1953

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Just Scratching the Surface

—*Starts on Front Cover*

and growing field of the engineering profession.

When Mr. Harza opened his own consulting office in Portland, Oregon, in 1912, the installed capacity of hydro-generating plants in the U.S. was slightly more than 1.5 million kilowatts. By the end of 1952 this figure approached the 20 million kilowatt mark. It is no exaggeration to say that in the intervening 40 years, Leroy Harza has been consulted on phases of planning, design, and construction of many of the projects that have constituted this growth in the hydro field.

Today, with the Harza Engineering Co. firmly established and with able associates to help him follow through on the $180 million of work presently on the books, Mr. Harza has been able to devote more personal time and interest to the foreign development of hydro-programs.

The control and utilization of river waters that started to take place in this country at the turn of the century is now beginning to effect similar revolutionary changes in the backward countries of the world. Irrigation, flood control, land reclamation and industrialization, all follow in the wake of dams and power generating stations. Leroy Harza has participated in such projects from Alaska to Uruguay and from the Philippines to India.

Leroy F. Harza, Consulting Engineer, born in Brookings, South Dakota, in 1882, passed away quietly in his Highland Park, Illinois home, November 22, 1953. This story is one tribute to his memory.

In Uruguay — the 120,000 kw Rio Negro Hydro Development was completely designed, equipment purchased, and expedited by Harza—from the dam and power plant to the sub-stations and distribution systems. The job was taken over at an early stage in 1941 when the original German engineers were forced out by the war.

In the Philippines—comprehensive studies are being made for the ultimate development of 430,000 kw from the Agno River Basin. A 430 ft dam and hydro station are already under construction.

In El Salvador—Harza is responsible for the design and supervision of a 75,000 kw hydro plant which is now nearing completion.

In India—there is a version of our own TVA in the Damodar Valley Corp. Harza, as chairman of the consulting board, and with a contract to design two of its projects, has made seven trips to India in the last three years planning the comprehensive development of the Damodar River (see CONSULTING ENGINEER, March, 1953).

While the foreign work assumes greater importance because of the backwardness of these countries and the tremendous impetus that these river development projects will have upon their economies, it is in the United States that Harza gained the knowledge and experience that has made his reputation.

A mechanical engineering graduate from South Dakota State College in 1901, Harza supplemented his mechanical background with a civil engineering degree from the University of Wisconsin in 1906. Initially, he worked with a number of other consultants specializing in hydroelectric engineering. Between 1912-1916 he had his own consulting office in Portland, Oregon. Then in 1920 he formed the consulting firm in Chicago which bears his name.

Harza early received prominent attention when he completely designed and supervised the construction of the Dix River Dam and Hydroelectic Project in Kentucky built in 1922-24. Later, in 1934-37, a 50,000 kw hydro-plant for the Loup River Public Power District in Columbus, Nebraska, which was built under his direction, received similar notice.

A solid and widely recognized achievement was the Santee-Cooper Hydroelectric and Navigation Project built between 1938-42 near Charleston, South Carolina, with an ultimate generating capacity of 173,000 kw. The Harza Engineering Co. furnished complete engineering services and construction supervision for the entire Santee-Cooper project.

In 1941-42, preliminary design, reports, estimates, and specifications for the International Rapids Hydroelectric Project of the St. Lawrence River were prepared for the U. S. Army Engineers. When constructed, this will be one of the world's largest hydro-generating stations with a proposed capacity of two million kw.

Almost 72 years old, Leroy Harza is not content to rest. One outlet for his energies has been to actively promote better utilization and control of river waters, both in this country and abroad.

Returning from his travels in the backward countries of the world, he finds it hard to comprehend so much poverty and hunger in lands that are naturally endowed with resources. Proper development of the water resources alone can substantially raise the standard of living of the people and even advantageously alter the entire economy. With these goals in mind, Harza is naturally enthusiastic about the contribution that American engineering and construction know-how can make. The surface has hardly been scratched, says Harza, and by helping to show the way, he hopes others will follow.

Outspoken, blunt, sometimes caustic, and always to the point, Leroy Harza sees his dams, hydro-projects and generating stations, as tangible proof of what American "free-enterprise" can do.

SCRAPS & SHAVINGS

THE ENGINEERING SOCIETIES are facing a serious housing problem. The building at 29 West 39th street, New York in which the four Founder Societies are located is old and crowded — no longer satisfactory as a headquarters building. This building is owned by the Founders Societies through a trust fund set up under New York law. The original money for the building came from Andrew Carnegie, and the property is administered by the United Engineering Trustees. Each Founder Society is represented on UET, and it will be up to these men to develop some solution to the Societies' housing problem.

Recognizing this as an opportunity not to be missed, a number of cities have made bids and offers designed to encourage the societies to relocate in their area. The offers from Pittsburgh and Chicago are specific to the extent that in each instance land and money are offered for the building of a large Engineering Center which would house not only the offices of the Founders Societies, but a number of other respected engineering organizations.

Despite the newspaper stories from Pittsburgh and Chicago, little action has been taken. For example, at the recent ASME meeting, Council approved a Declaration of Intent, a paper which each Society on UET is being asked to approve. This is a statement to the effect that the Societies want to keep living together — that they do not intend to go out separately, each to find its own future location.

Council then tried to decide whether they had the constitutional right to take action for the Society on the question of a headquarters move. It was agreed that they did not have that power, so a letter ballot is being sent to all members asking that such powers be conferred upon them.

It does seem that there is strong sentiment favoring a move from New York. However, even if this sentiment were unanimous (which it certainly is not) there would be legal difficulties involved. Some of the passages in the bill setting up the trustee agreement would seem to make it difficult to move the headquarters from New York State without the loss of funds derived from the original Carnegie grant. United Engineering Trustees feel that these conditions imposed on the trust fund are a serious barrier to movement from New York, but not an impossible one. A court test will be made.

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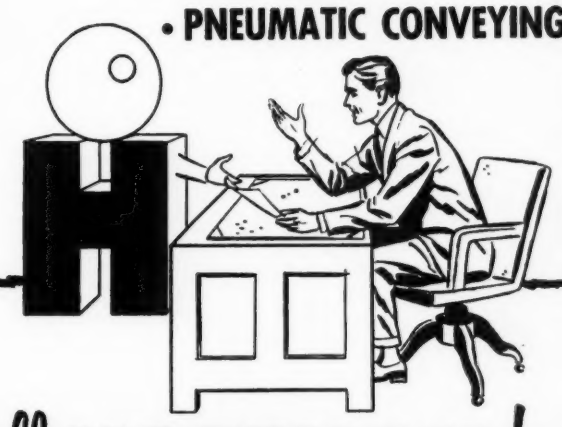

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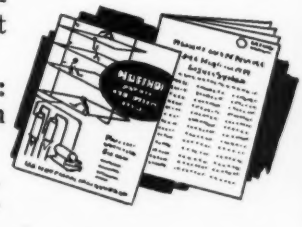

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Unification

Sir:

I have just got around to reading my October issue of CONSULTING ENGINEER, and I am amazed as I am gratified by the hard hitting but fair and accurate analysis of the "unity" situation under "Scraps and Shavings." I should like to know the name of the author so that I may congratulate him both on his courage and his perspicacity.

W. F. Ryan,
Engineering Manager
Stone & Webster Engineering Corp.
Boston, Massachusetts

Sir:

The author of your feature, "Scraps & Shavings," as set forth in the October issue of CONSULTING ENGINEER is not indicated. He should be congratulated upon an honest and forthright report of the conditions existing among the various engineering societies. You and your staff are also to be congratulated for having the courage to publish his report.

You realize, of course, that henceforth you will be classified by those who actually manage some of the national societies as being among those "Communists" who dare to criticise their methods of management. We of the Colorado Society of Engineers together with the Colorado units of many of the national societies have already been classified among those "Communists" because we have dared to suggest that proprietary interests and pride of organization should be suborogated in the interests of an effective, unified engineering organization.

All of us who have seen it were especially pleased with the "Scraps & Shavings" article. We feel that it deserves wide distribution. The purpose of this letter is to request permission to reprint the article to provide a wider distribution. We would, of course, give due credit to CONSULTING ENGINEER.

Alfred J. Ryan, President
Colorado Society of Engineers
Denver, Colorado

● AIN'T NOBODY HERE BUT US EDITORS

Free Piston Comment

Sir:

Your article "Free Piston Engines", in the August issue of CONSULTING ENGINEER is of great value to the profession. It helps to take the mystery out of the subject. Permit me to compliment you on the lucidity of the description of this "engine."

If discussion is permitted, may I add the following. In 1862, Beau de Rochas described a cycle in which he included compression of the charge in an Internal Combustion Engine. In 1876 Otto developed an engine based on this principle, which established the gas engine on a firm basis.

In any internal combustion engine, the piston has the dual function of compressing the charge and delivering power. For the reason of continuity we have multi-cylinder engines, so that at every stroke we may have "power" pistons and "compression" pistons. Instead of having the pistons in parallel, we can arrange them in tandem, the front piston delivering power while the other is compressing. In order to make use of the advantages of the double-acting engine while retaining the simple construction of the single acting, the opposed piston engine has been developed.

The free piston engine is simply the opposed tandem piston. If the engine is used as a reciprocating compressor by burning fuel to produce mechanical work in the form of compressing air, then, and then only, is it an engine, or prime mover. A prime mover is an apparatus that converts heat energy into mechanical energy. However, when used in conjunction with a gas turbine, it is not a prime mover, but a gas generator.

The gas turbine is the most significant engineering development of the twentieth century. The gas turbine is the only mechanical phenom-

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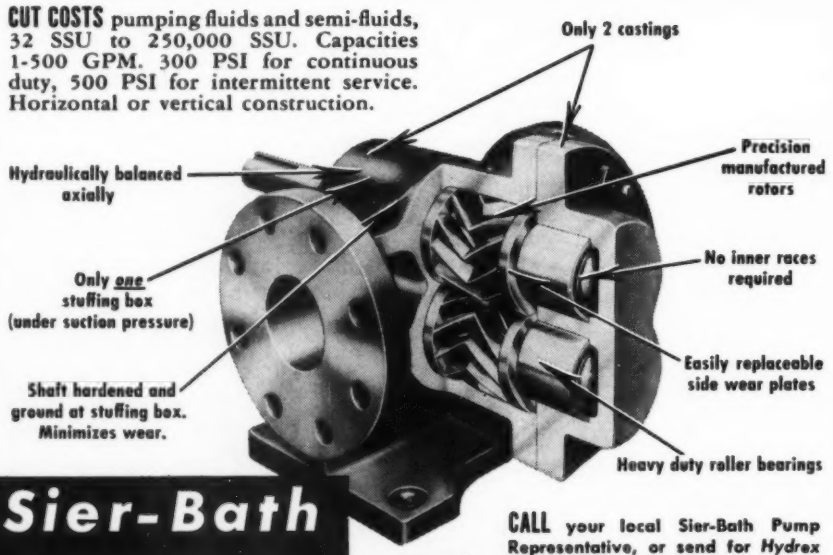
CUT COSTS pumping fluids and semi-fluids, 32 SSU to 250,000 SSU. Capacities 1-500 GPM. 300 PSI for continuous duty, 500 PSI for intermittent service. Horizontal or vertical construction.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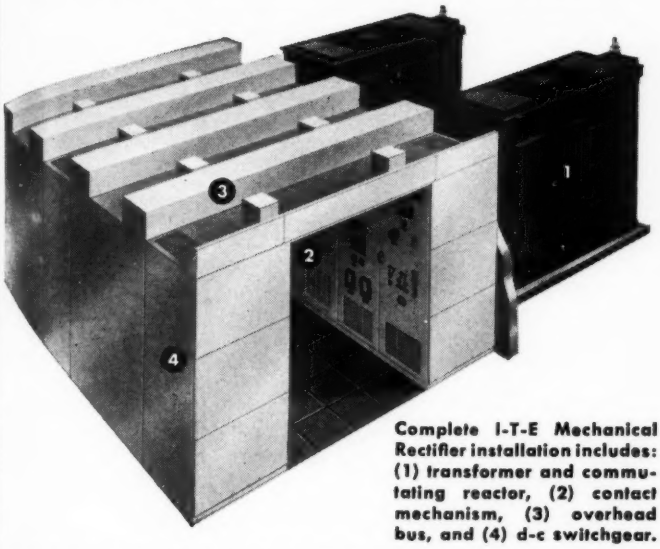
MECHANICAL RECTIFIERS



Complete I-T-E Mechanical Rectifier installation includes: (1) transformer and commutating reactor, (2) contact mechanism, (3) overhead bus, and (4) d-c switchgear.

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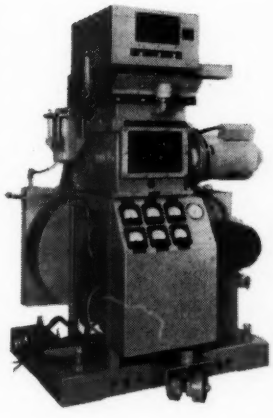
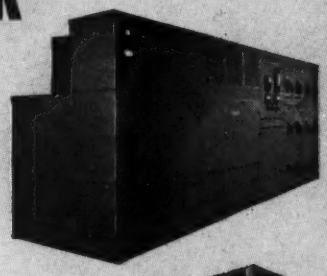


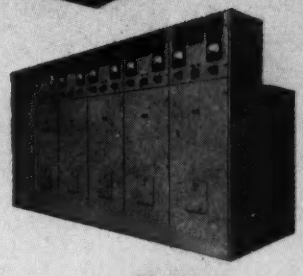
5,000-ampere contact mechanism. Multiple 5,000 and 10,000 ampere mechanisms are operable in parallel.

SWITCHGEAR



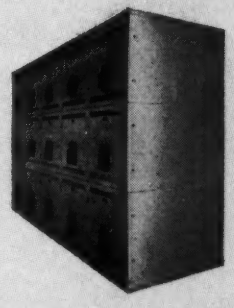
Unit Substations

For applications requiring primary or secondary types; indoor or outdoor installation; oil, askarel, or air transformers. Switchgear is of I-T-E metal-enclosed construction with drawout-mounted air circuit breakers.



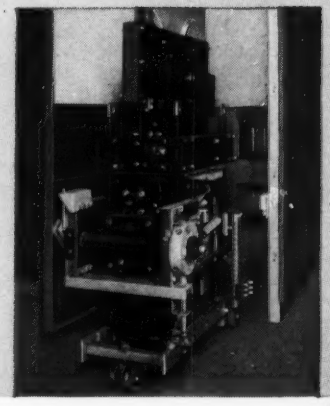
Metal-Clad Switchgear

For reliable protection, based on proved interrupting capacity, I-T-E provides factory-assembled and -tested switchgear, shipped as a unit, ready for low-cost installation. I-T-E air circuit breakers are horizontal-drawout mounted, featuring simplified disconnect and test with doors closed.



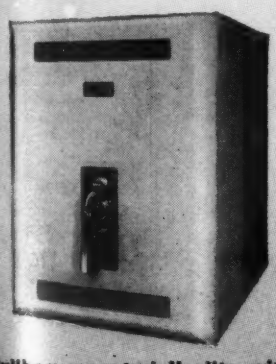
Low-Voltage Switchgear

For reliability and long life with reduced maintenance, I-T-E has metal-enclosed switchgear featuring pantograph, drawout air circuit breakers with complete range of ratings and widest selection of protective devices. Structures are exceptionally rugged and durably finished.



D-C Circuit Breakers

For interrupting heavy direct currents, as for protection of rotating machines and rectifiers, I-T-E provides specially-developed circuit breakers combining very rugged construction with fast circuit-opening and reliable arc extinction. Available auxiliary devices make these circuit breakers widely applicable.



Pullbox-mounted Urelite with all live parts enclosed for safety and dependable performance.

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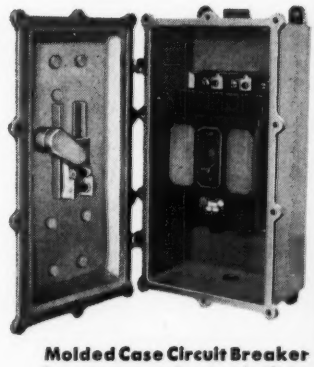

Molded Case Circuit Breaker in approved explosion-proof enclosure.

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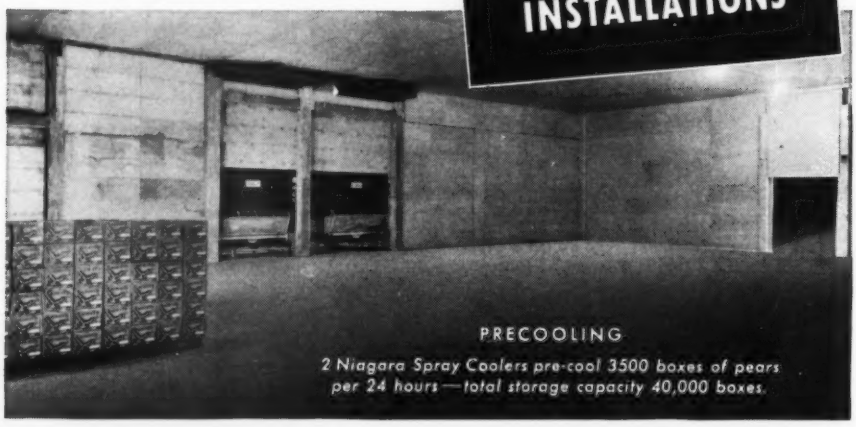

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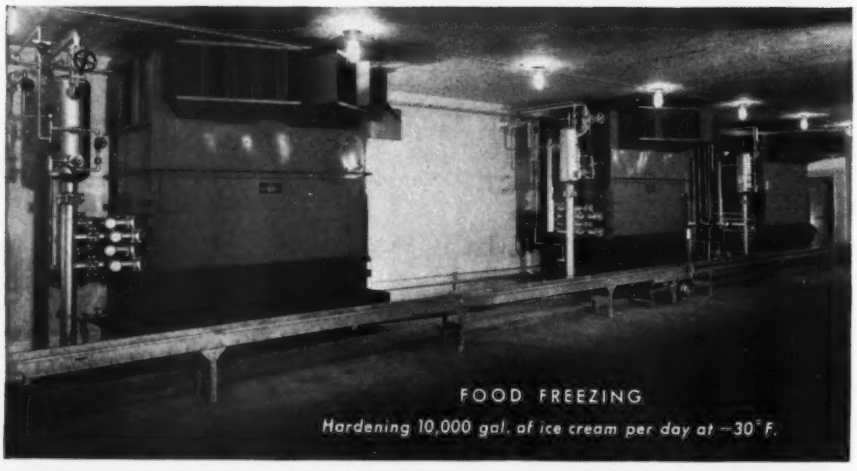

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enon to come close to man's desire for the direct creation of power from heat. It broke the tradition of copying the military cannon. As a prime mover, the turbine needs a compressor. If the opposed piston type compressor is more efficient than the centrifugal, the gas turbine can use the free piston as a gas generator, but only up to the time the centrifugal compressor can be developed to give better compression. It is the compression ratio of the air for combustion that determines the efficiency of this engine.

This much is clear, we must abandon the crankshaft and the intermittency of our prime movers. The free piston engine is still shackled to the principle of intermittency. The gas turbine, on the contrary, is a continuous rotation, continuous combustion, and continuous compression prime mover.

Jacob Yavitch, Consulting Engineer
Glen Olden, Pa.

Serving The Consultants

Sir:

Will you kindly furnish the address of the Device Development Company that makes the clip pencil slide-rule as shown on page 60 of your October issue.

R. C. Tackenberg
R. C. Tackenberg and Associates
Cincinnati, Ohio

● THE HANDY CLIP PENCIL WITH SLIDE-RULE SCALES SELLS FOR $4.98 AND MAY BE ORDERED DIRECT FROM DEVICE DEVELOPMENT COMPANY, 226 EAST 4TH STREET, NEW YORK 14, NEW YORK.—ED.

Sir:

For your magazine, CONSULTING ENGINEER, we wish to offer our sincere appreciation.

Your article "Engineers Need Ethical Discipline" in the June issue, is a powerful article that we would like to see widely circulated. If possible, we would like five reprints for this purpose.

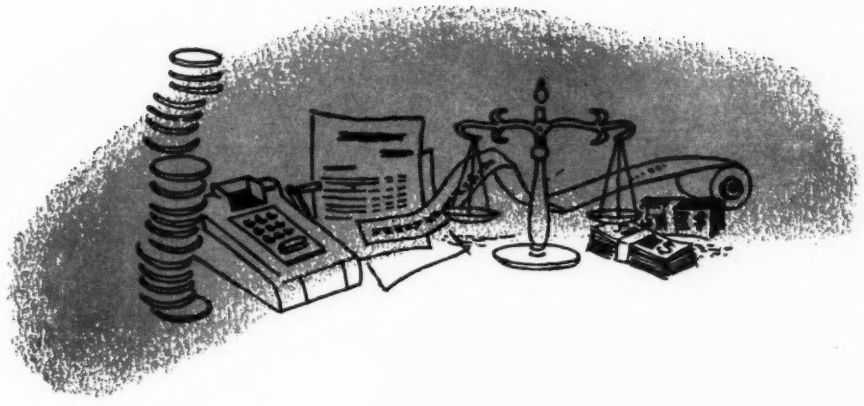
We would also like tear sheets or a reprint of Carl Heyel's article on the "Engineering Study of New York," and the article by V. W. Palen entitled, "Your Firm Can Afford Publicity," both in the June issue.

Your issues of May to August inclusive have been sent to us, and we would like to receive the magazine regularly, including issues we have missed. Will you kindly quote us on these?

Your magazine fills a great need, and we wish to extend our best wishes for your continued success.

John R. Campbell, President
Rutherford Campbell Engineers, Inc.
Buffalo, New York.

ECONOMIC NEWS NOTES



E. F. Mac Donald
INDUSTRIAL ECONOMIST

CE ECONOMY—Headlines (National Association of Real Estate Boards) tell the story of how Federal economy can begin on the local level. Franklin County, Idaho, needed a dam across a local river to prevent heavy wash-away of topsoil. Federal surveyors estimated a cost of $500,000 and recommended the use of Federal funds. Franklin County, however, elected to do the job itself. A consulting engineer was hired who helped work out a plan for using local materials and labor—and local funds. Result: final total cost of $39,745—8% of the Federal experts' estimate.

TACIT AGREEMENTS — Contractors and unions can't evade the Taft-Hartley ban on closed shops by having tacit agreements to hire only union members. In a decision against Construction Specialties Co. of Denver and AFL asbestos workers, the U.S. Court of Appeals, in Denver, supported an NLRB interpretation that such agreements are as illegal as written contracts not to hire workers not cleared by unions.

MACHINE AGE—Technological progress is cited as a major factor in the almost four-fold expansion of purchases of equipment in recent years. In a comprehensive study of investment in productive equipment from 1929 to 1952 published in the November 1953 issue of "Survey of Current Business" (U.S. Department of Commerce), it is shown that all of the 20 major groups of equipment studied experienced increased sales. Machinery registered the greatest gain, increasing its share of total equipment purchases from 48% in 1929 to 58% in 1952.

POLLUTION PROBLEMS—Water pollution is a major industrial and municipal problem that is beginning to receive attention on a major scale. It has been estimated that in the 2nd quarter alone of 1953, $65 million of contracts were placed by municipalities to curb pollution and conserve water resources. Next on the docket should be smog—the air pollution problem.

CAPACITY WANTED—Additional capacity in 68 production fields is still needed to fill "gaps in the mobilization base," announced Defense Mobilizer Flemming. The expansion goals still open include primary aluminum, 30 and 50 cal. "ammo" boxes, steam boilers, gray iron castings over 3,000 lbs, oil storage facilities, tankers and ore carriers, and steam turbines. Dr. Flemming stated that if applications are not forthcoming, the Government would have to make other plans, including building its own stand-by capacity.

MODERN MUSHROOM—Plans are reported to be well along for construction of a new city of 50,000 people near Laurel, Maryland. The 2,000-acre project is about a quarter-hour drive from Baltimore, and upon completion of a new highway will be about the same time-distance from the nation's capitol.

INDUSTRIAL ENGINEERING—Prof. Mundel, Marquette Univ., told a recent meeting of the Industrial Management Society that its most critical problem is "Where can industrial engineering training be obtained?" He stated that he knew of only 27 engineering schools with accredited courses in industrial engineering. He warned that the number was liable to decrease rather than increase in the near future.

COOPERATION INCORPORATED—A new company—The Nuclear Power Co.—has been formed by and will be owned by a group of four power companies: American Gas & Electric, Commonwealth Edison, Pacific Gas & Electric, and Union Electric; and The Bechtel Corp., an engineering firm. The joint owners stated that the initial objective of the new company, approved by AEC, is to select a reactor design intended primarily for the production of electric power in the near future and to make a preliminary economic appraisal of the design.

ONLY 2% OFF—A joint report on new construction in 1954 by Commerce and Labor estimates total outlays of $34 billion. Although this would be the first year-to-year decline in 8 years, it would be only 2% less than the record volume of 1953. Private outlays are expected to be off 3%, and public construction down only 1%. The latter would likely be replaced with an increase if private investment slides off seriously. Declines in private housing, industrial plant, farm construction, and defense facilities are looked to be offset by gains in utilities, stores, schools, roads, and other state and local projects. It is assumed that mortgage funds will be adequate and that building costs will be fairly stable.

90% RIGHT—An analysis has been made of the Monthly Reports by the Business Survey Committee of the National Association of Purchasing Agents by Dr. Luedicke, Editor of the "Journal of Commerce." Entitled "The Effectiveness of Opinion Surveys," it reveals that the predictions of prices, production, new orders, inventories, and employment in manufacturing by the Survey Committee, from January 1947 to October 1953, were 90% correct.

ATOMS IN ACTION

POTENTIAL ENERGY — From Lewis L. Strauss, chairman of the Atomic Energy Commission comes the estimate that the energy potential of fissionable material in sight is at least 23 times that of the existing reserves in conventional sources of energy. To bolster the reserves of atomic energy, it is suggested by some that better use should be made of the atomic fuels themselves; we presently convert but one-tenth of one percent of an atom's mass into energy in the uranium reactions now used.

NO CHOICE — We have no choice but to go ahead and push the commercial development of atomic energy for power production. Such is the view of A. C. Monteith, Westinghouse's vice president in charge of engineering. Atomic power is the most promising way of closing the gap between our limited energy reserves and our growing appetite for energy. Monteith predicts that we will burn up more energy in the year 2000 than was used from 1 A.D. to the present. "We believe that nuclear energy ultimately will be competitive with present sources" said Monteith.

ATOMIC INSTRUMENTATION — By using radiation from the radioisotope strontium 90, a new instrument can reduce a basic control test from four hours to 5 minutes and double its accuracy at the same time. The device measures percentage hydrogen and the H/C ratio in liquid hydrocarbons by a process dependent on the absorption of beta rays. The present application is to in-process control of petroleum being refined; other applications are expected in processing pharmaceuticals, chemicals, plastics, and foods.

TAGGED ATOMS — The radioactive by-products of atomic reactors are making possible many new studies on the basic mechanisms within plant and animal life. By following the progress of these radioisotopes within the subjects, data is being accumulated on such fundamentals as metabolism and the minute effects of mineral deficiencies. Radioactive carbon dioxide is yielding up important information on the mechanisms of photosynthesis; the assimilation of the carbon dioxide by plants is clearly determined. Fermentation is another natural process getting the eagle eye through the use of tagged atoms.

MORE PATENTS — The Atomic Energy Commission has released 21 more patents for public use, bringing the total released to 614. The latest batch includes an electrolytic cell for producing fluorine, a resistance measuring device, an electromagnetic centrifugal pump for handling electrically conductive fluids, a method of forging metals, a vapor detector, a pulse generator, and a process for the production of radioactive substances. Inventors cited include a Mr. Fermi -- and a Mr. Smith.

HANFORD HEAT — For the first time in history, heat from atomic reactors will be used to warm buildings. General Electric has announced that waste heat will be extracted from the cooling waters of its Hanford reactors and used to heat several buildings. The initial investment will be $614,000 compared to $17,000 for a conventional system; but the operating costs will only be $2200 yearly compared to a conventional fuel bill of $61,200 yearly.

TWO CLYDE MODEL 24-E-115 WHIRLEYS at Kerr Dam, Va., each with capacity of 30 tons on boom, 10 tons on jib.

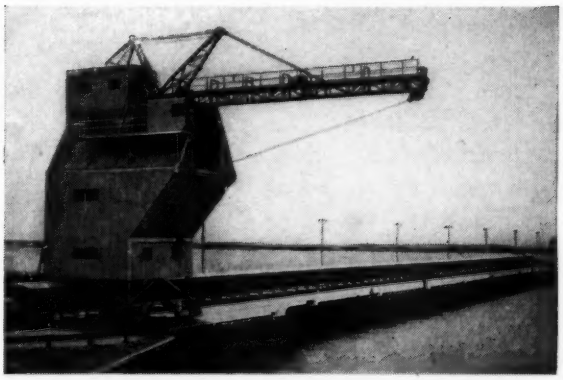
Strong-arm tactics on the Roanoke

Reaching for the sky at new Kerr Dam built by the Corps of Engineers on the Roanoke River in Virginia is a habit with this husky pair of Whirley gantry cranes made by Barium's Clyde Iron Works, Inc., Duluth, Minn.

Equipped with 100-ft. booms and 15-ft. jibs, the "Whirleys" poured concrete and handled other materials across all but the extreme ends of the 22,285-ft. dam, longest in the U. S. When complete, 144-ft. high Kerr Dam will back up an 83,200-acre "pond" for flood control, power generation and recreation.

These long-armed giants are samples of the complete line of construction machinery and materials you can get from Barium — power hoists, derricks, builders' towers, as well as structural steels, fabricated forms and fasteners of every type. You get what you want in a hurry, too. Barium's 16 companies function as an integrated unit that supplies engineering assistance, controls quality and speeds delivery . . . taking a load of detail work off your shoulders.

All this is at your disposal right now. Write Barium Steel Corporation, 25 Broad St., New York 4, N. Y.



NEW CLYDE ORE UNLOADER on duty at a southern port. Unloading bauxite ore from ship to conveyor belt, this mechanical "stevedore" digs at a 300-ton-per-hour clip.

3.39

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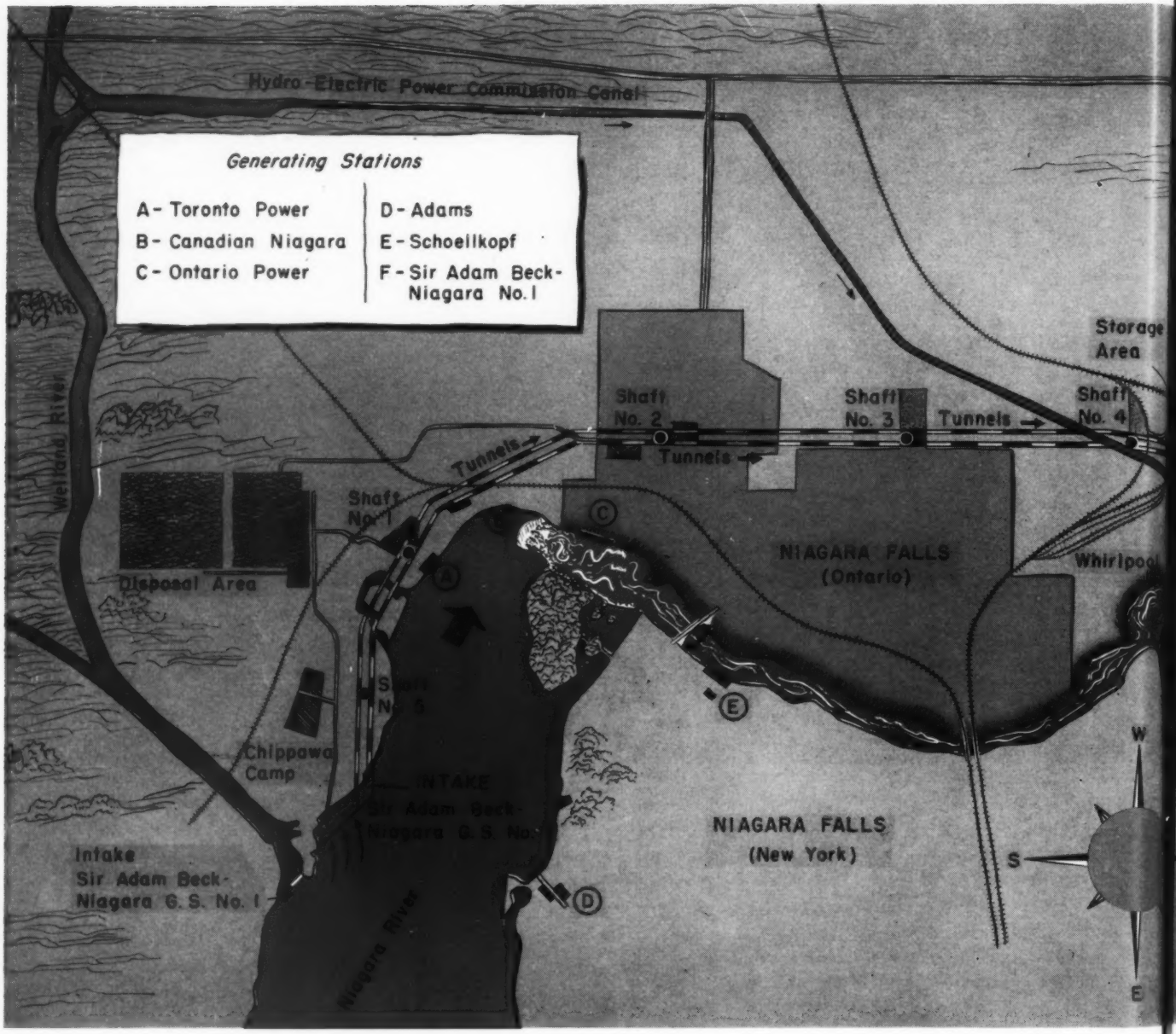


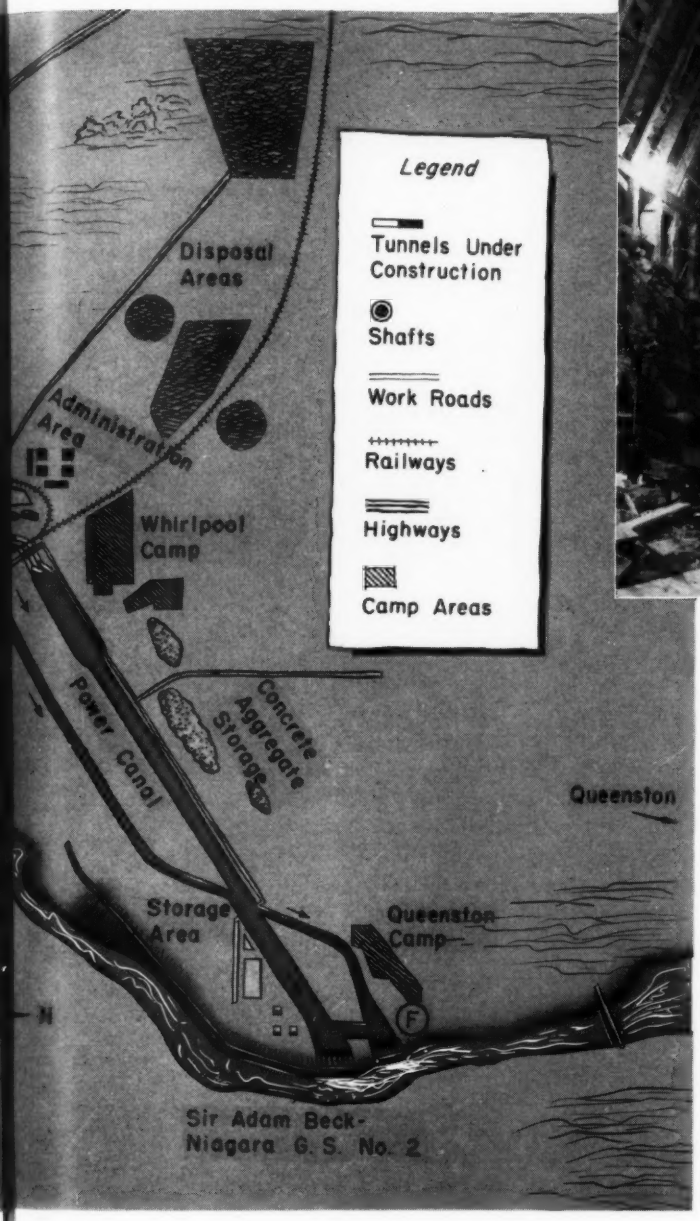
Ontario Makes Progress at Niagara

ROBERT GORDON DYMENT

CUT INTO THE CLIFFS of the Niagara River are the Hydro-Electric Power Commission of Ontario's two great sources of power, the Sir Adam Beck-Niagara Generating Station No. 1 and the new Sir Adam Beck-Niagara Generating Station No. 2. When the new station is completed, the two power plants will have a combined installed capacity of approximately 2,353,000 horsepower.

The new station will cost $343 million, and will have an ultimate installed capacity of 1,828,000 horsepower. It is scheduled to begin initial operation in 1954, with all twelve generating units to be in service by 1956. The new plant, which is being built into a 300-foot cliff in the lower Niagara River Gorge, is located six miles below the Falls—immediately upstream from the No. 1 station.

Water for the new station will be diverted from the upper Niagara River through two intake structures and will be conveyed beneath the city of



CONSTRUCTION VIEW OF COMPLETED PORTION OF TUNNEL SHOWS 3-FOOT THICK CONCRETE LINING.

Niagara Falls, Ontario, by twin tunnels. Emerging to the surface on the other side of the city, the 5½-mile tunnels will empty into a 2½-mile canal which will carry water to the station.

Forty thousand cubic feet of water will pass through the tunnels every second, for a total of 21.6 billion gallons a day.

Each of these tunnels has an unfinished diameter of 51 feet, which will be reduced to 45 feet when the smooth concrete lining has been applied. As far as is known, no hydraulic tunnels in the world are comparable in terms of combined length and diameter to those being constructed by the Commission at Niagara. By way of comparison, the four diversion tunnels at Boulder Dam have a 56-foot unfinished bore and a 50-foot diameter when lined, but their total length is just 16,000 feet.

Three of the tunnel sections are being built for the Commission by Perini-Walsh and Associates. The remaining two are being constructed by Rayner-Atlas Company, a Canadian firm.

Boring of the tunnels calls for the excavation of approximately 4,375,000 cubic yards of rock, or 9,923,000 tons. Over 43,900 tons of structural steel will be used in the supporting I-beam structures, and approximately 1,933,000 tons of concrete will be used in surfacing the inside rounds of the two tunnels. Concrete is serviced to tunnel locations through 8-inch holes drilled from the surface.

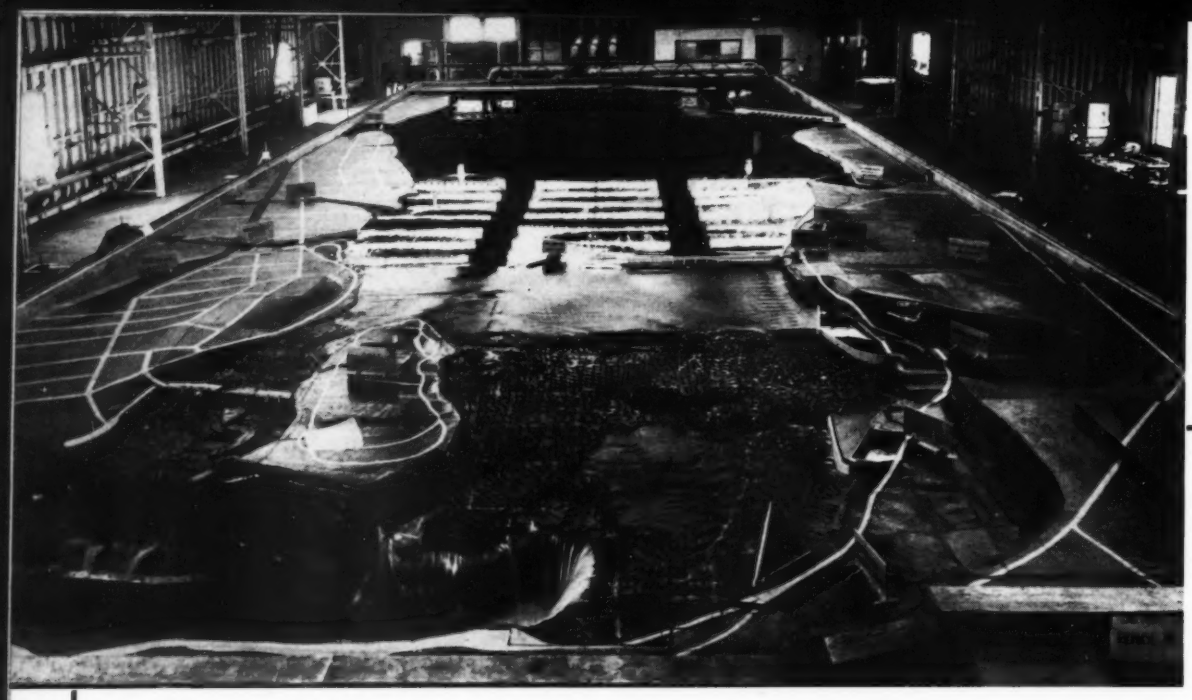
Tunnel Excavation

The greatest depth of the tunnels will be 300 feet below ground surface. The tunnels will rise to an elevation of 207 feet below ground level before emerging at a 30-degree slope to the open canal.

The tunneling method which has been the most successful at Niagara, and the only method now being used, consists of driving a top-heading which embraces slightly more than the upper semicircle of the face. Excavation of the invert grade is then completed by benching with vertical holes.

At the beginning of the project, however, the contractors of Sections 1 and 2 used a method involving the driving of a full-heading from arch to invert, leaving a narrow berm on either side to be excavated at a later stage. In this work, a two-part drill jumbo was used. The upper part rode on gantry rails laid along the top of the berm on each side, while the lower portion rode on rails laid on the bottom of the tunnel.

After establishing the routines, progress slightly in excess of 200 feet per week was achieved. However, because of the problems encountered in cleaning and scaling the large face area exposed, and the difficulties in handling steel at such a height above



Exhaustive tests, conducted on an exact scale model depicting a four-mile section of the Niagara River and the Falls, enabled The Hydro-Electric Power Commission of Ontario to save $5 million in the development of the new Sir Adam Beck-Niagara Generating Station No. 2. Most of the estimated saving resulted from findings which permitted cutting down excavation work.

Because the swiftness and turbulence of the rapids make it impossible for any boat to enter the maelstrom of water above the Falls, no correct chart of these channels had ever been prepared. To measure the depths of water from the tip of Grand Island to the edge of the rapids, a supersonic device was used to transmit sound waves through the water and record the time intervals of their echoes from the bottom. Below the rapids, to the brink of the cataract, a sounding weight was lowered from a helicopter to determine the elevations of the river bed. From the several hundred readings taken, it was possible to shape the channels of the model.

The model was constructed with a horizontal scale of 250 feet to 1 foot, and a vertical scale of 50 feet to 1 foot.

the floor, it was decided in the fall of 1952 to change over to the top-heading and bench method. The progress record, using the top-heading method, now stands at 469 feet for a six-day week.

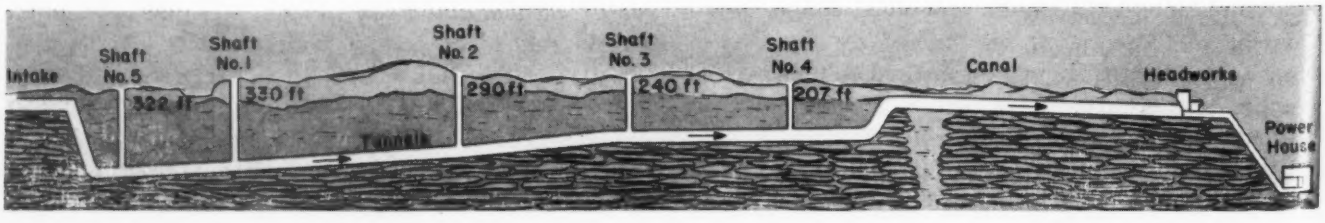
Each shaft is provided with a 4-foot diameter vent pipe, connected to a 75,000 cfm fan, to meet the heavy ventilation requirements. The fans are reversible and are used for blowing fresh air into the faces, except for a short period after blasting when they are operated as exhausters.

Rock Formations

The sedimentary and historical geology of the area has influenced the excavation and design of the project. This is partly evidenced by the fact that preliminary survey work indicated need for about 16,840 feet of diamond-drilling. Revised information has increased this figure to 50,000 feet.

The rock strata in this area were laid down in Ordovician and Silurian times, with successive elevations and depressions of the seas accounting for various members and formations. In general, the strata dip gently to the south-south-east at 28 feet to the mile, though diamond-drill intersections show occasional local dips up to 60 feet per mile.

The vertical elevation and invert grade of the tunnels were dictated by the necessity of maintaining a roof member of the greatest possible com-



PROFILE OF THE TWIN TUNNELS BEING CONSTRUCTED FOR SIR ADAM BECK-NIAGARA GENERATING STATION NO. 2.

petence, including freedom from cross-bedding and other stratigraphic irregularities. This requirement was best met by a strata of Irondequoit limestone in the Clinton Formation.

This limestone is pink to gray in color, coarsely crystalline in texture, and quite fossiliferous. In physical structure, it is coarse, dense, massive to poorly bedded, and is relatively unjointed. Its upper and lower contacts are abrupt and clearly-defined. Except for minor variations dictated during progress, the arch of the tunnel is maintained on the lower contact of the Irondequoit member, thereby determining its vertical position and its grade of about 28 feet per mile upward in direction of eventual water flow.

From arch to invert, the formations exposed in the tunnel faces consist of 12 feet of Reynales dolomite, 6 feet of Neagha shale, 8 feet of Thorold sandstone, and 25 feet of Grimsby sandstone.

The Reynales is a green-gray to steel gray, fine-grained dolomite in 1 to 6 feet thick individual beds separated by well-developed thin shale partings.

The Neagha basal member of the Clinton Formation consists of 6 feet of soft, fissile, greenish-gray

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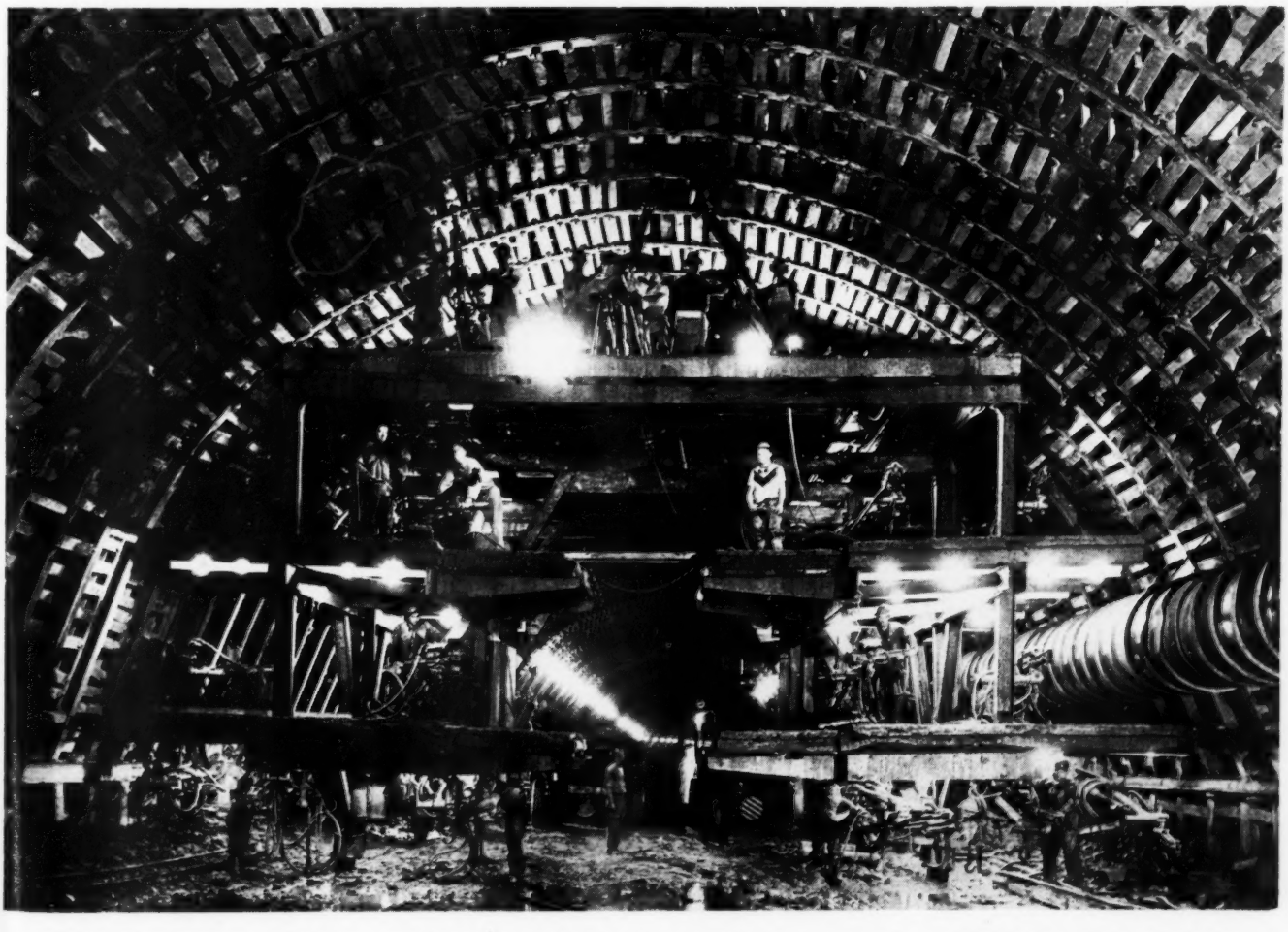
MOBILE "SKYLIFT" PERMITS CLOSE-UP EXAMINATION OF HARD-TO-GET-AT SECTIONS OF THE TUNNELS.



THREE-DECK JUMBO, USED IN TOP-HEADING, MOUNTS 17 HYDRAULIC JIBS FOR POSITIONING THE DRIFTERS.

INCENTIVES BASED ON TIME STUDY ARE USUALLY UNPOPULAR WITH THE PEOPLE THEY ARE SUPPOSED TO BENEFIT.

Management and Incentive Systems

VICTOR K. GENGER
Vice-President
McClure, Hadden & Ortman, Inc.

Victor K. Genger is an authority in the techniques of work measurement as related to human relations. Co-author of the "Handbook of Standard Time Data for Machine Shops", The Ronald Press, 1954, he is also one of the registered practitioners of Methods Time Measurement and a director of the M.T.M. Association for Standards Research.

INCENTIVE SYSTEMS, while designed to help management standardize and control manufacturing costs, are also set up to benefit the worker. The concept of payment for accomplishment of task is an integral part of any incentive plan, and the idea of "putting the worker in business for himself" should be popular with the workingman. In most cases it is not. In fact, it is so violently disliked, that more and more managements are asking, "Is it worth the trouble?"

Unfortunately, for those who decide that incentives are not worth the trouble, experience indicates

that production usually declines by about 50 percent if incentives are removed. Evidence tends to indicate that incentives are an effective spur to production, and once installed, dangerous to tamper with. It is difficult to determine why this is true, and even more difficult to find an effective course of remedial action for these conditions.

The Human Factor

Basically, the trouble with incentives is that they are closely associated with human effort and consequently with human beings. Apparently, nobody likes to be judged. Especially, nobody likes to be observed as closely as stopwatch time study requires and then told, perhaps, that their way of doing the job is wrong, or that they were not working hard enough at their operation.

It logically follows that administration of an incentive plan is difficult, controversial, and unpopular. There is too much left to the judgment of the rate setter. It is possible to treat individuals differently by leveling, inclusion of unnecessary work elements, or introduction of wrong methods.

Administration

Difficulties attendant to incentive systems may arise out of the tendency of management and worker alike, to regard incentive pay earned as at least partially guaranteed. If a worker is accustomed to earnings of $2.25 per hour on an incentive job, he is very unhappy if he is assigned to a job with no standard and is guaranteed only his base rate of $1.70. In fact, management has generally emphasized the $2.25 potential in presenting the job to the worker. Because the worker on a non-standard job is not receiving what he believes to be his rightful earnings, he feels that management has taken advantage of him.

Some managements, in trying to adjust this area of apparent inequity, have established practices of guaranteeing rates other than the base rate of the job, such as average earnings or expected earnings, to avoid "penalizing" the worker. This practice usually has the effect of making non-incentive jobs more attractive than incentive jobs. From management's viewpoint, this is undesirable.

Primarily, the fault is that all concerned are prone to regard the incentive earnings as a vested interest rather than an opportunity. It is difficult to present a cure for this attitude, but the area can be reduced by an all-out effort to attain full coverage of all operations with standards.

A corollary source of discontent on the part of workers and management is the contest of methods that is introduced if a worker develops a method, or even a tool, which will reduce the time required to perform a task under standard. The worker regards the result of his ingenuity as his "incentive" and will guard it jealously, resisting the adjustment resulting from the incorporation of the change in the prescribed method of doing the job. Line supervision has been known to support and justify this stand. The major flaw in the argument is that such a policy will foster inequities and eventually make the introduction of management sponsored changes difficult, if not impossible.

The methods used for performing a job under standard should be clearly specified. The introduction of methods changes, no matter how minor, should be meticulously recorded, and the effect of "creeping changes" analyzed. This may not be easy when stopwatch time studies are used for establishment of standards because the detail is not always recorded. However, it is relatively easy when a standard data method is used. The existence of inequities in earning opportunities is probably the most serious and common of those plaguing management in administration of an incentive plan.

Penalty Clause

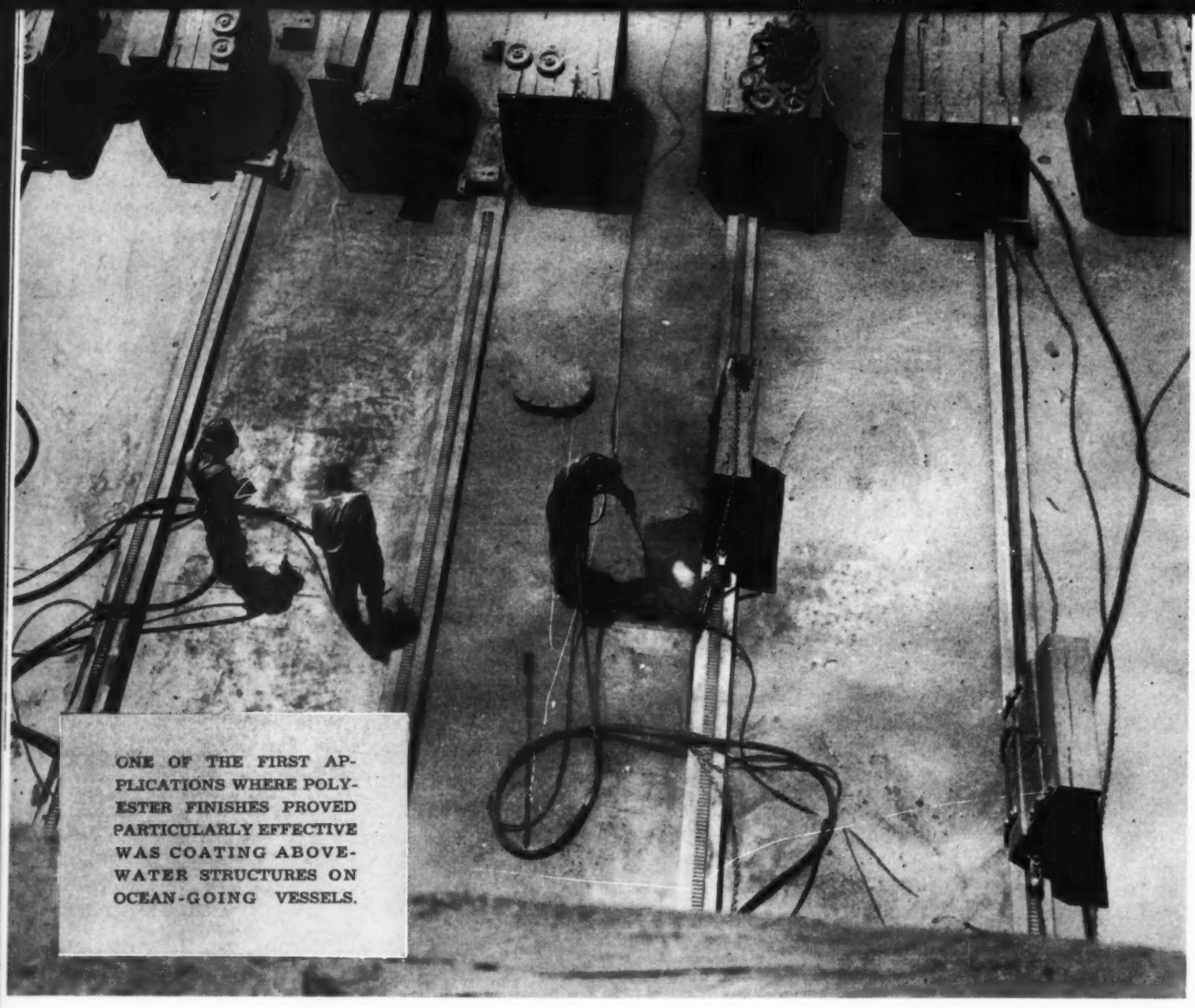
Finally, there is one factor which contributes to the inefficiency of many incentive plans. Simply, it is the lack of penalty for sub-standard production. To be fully effective, an incentive system should pay a higher reward for high production and have a penalty for unsatisfactory work. In these days of high guarantees and tight labor markets, it takes a lot of courage to enforce penalty clauses. Nevertheless, this is one of the faults of most incentive administrations. A changing economy may naturally correct this trend.

Nearly everyone agrees that there is not much wrong with the philosophy of incentives if person-

Continued on page 60

RECORD OF PERFORMANCE ON TRANSITION FROM DAYWORK TO INCENTIVE WORK AT A METAL WORKING PLANT

Part Name	*Day Work Cost*	*Incentive Cost*	*Percent Reduction*
Cylinder	$ .816	$ .436	53%
Steering Handle	.483	.210	57
Muffler Screw Nut	.051	.016	69
Crankcase Assembly	.091	.031	66
Carburetor Body	1.160	.347	.70
Connecting Rod	.306	.115	63
	2.907 (Total)	1.155 (Total)	60.4 (Avg.)



ONE OF THE FIRST APPLICATIONS WHERE POLYESTER FINISHES PROVED PARTICULARLY EFFECTIVE WAS COATING ABOVE-WATER STRUCTURES ON OCEAN-GOING VESSELS.

Finishing With Polyesters

FRANK CHARITY

ALTHOUGH BEST known as molding, laminating, or casting materials, polyester plastics are—actually and potentially—the most important organic coating resins. Polyesters are generally conceded to be one of the more remarkable technological developments made by the United States during World War II.

The term "polyester" was originated for the primary purpose of misleading enemy scientists who had access to American technical publications. A number of important polyesters were developed during World War II, but the actual history of these remarkable resins dates back to 1847—when the great Swedish chemist Jöns Jacob Berzelius first prepared glyceryl tartrate. The resins' now-common name is not a complete misnomer since it indicates that they comprise "many esters." However, it could be accurately used to designate many substances which are non-resinous.

Alkyd Resins

Most polyesters used for finishing purposes are alkyd resins, made by combining polyhydric alcohols and polybasic acids. The alcohols include glycerol, glycols, and dipentaerythritol. Typical acids which may be used are phthalic anhydride, maleic acid, and the succinic acids.

Despite their long history, polyester resins were not extensively used in the United States prior to World War II because there was no great need for synthetic materials in most branches of American industry. However, enough laboratory work was

accomplished to permit the large-scale production of these resins soon after wartime material shortages developed. And many people were surprised to find that polyester substitutes were better than the materials they replaced.

Seaworthy Finishes

For example, Navy men were pleased to find that —despite a previous misconception—alkyd coating resins were better than many finishing materials normally used to protect most areas above the waterline on seagoing vessels.

In some cases, unmodified polyesters have been satisfactorily used as coating materials. However, the general practicability of these resins results from the fact that they can be modified or compounded (with other resins, pigments, plasticizers, and drying oils) for a vast number of different finishing operations.

For example, they are modified with urea resins to produce white or light-colored coatings with superior color retention—as in finishing refrigerators, bathroom fixtures, and hospital equipment.

They may also be modified with rosin for use as lacquer sanding sealers, quick-drying enamels, furniture finishes, and linoleum varnishes. They are often modified with elastomeric materials for use in producing coatings and films that require maximum degrees of flexibility.

Most of the coating materials in use prior to World War II were polymerized resins dispersed in volatile solvents along with pigments and other substances. They were subject to considerable shrinkage on surfaces because their solidification was the result of solvent evaporation.

Polyester coatings differ from the dispersion-in-solvent type to the extent that they can be prepared as monomeric liquids, which polymerize or solidify as the result of internal chemical reaction following their application as finishing compounds. Since most monomers are relatively viscous (particularly so if they are mixed with dry powders), volatile solvents or thinners are often added to polyester solutions to facilitate their use as coatings. However, the quantities of solvents required for most finishing operations are not sufficient to cause large evaporation losses and excessive shrinkage.

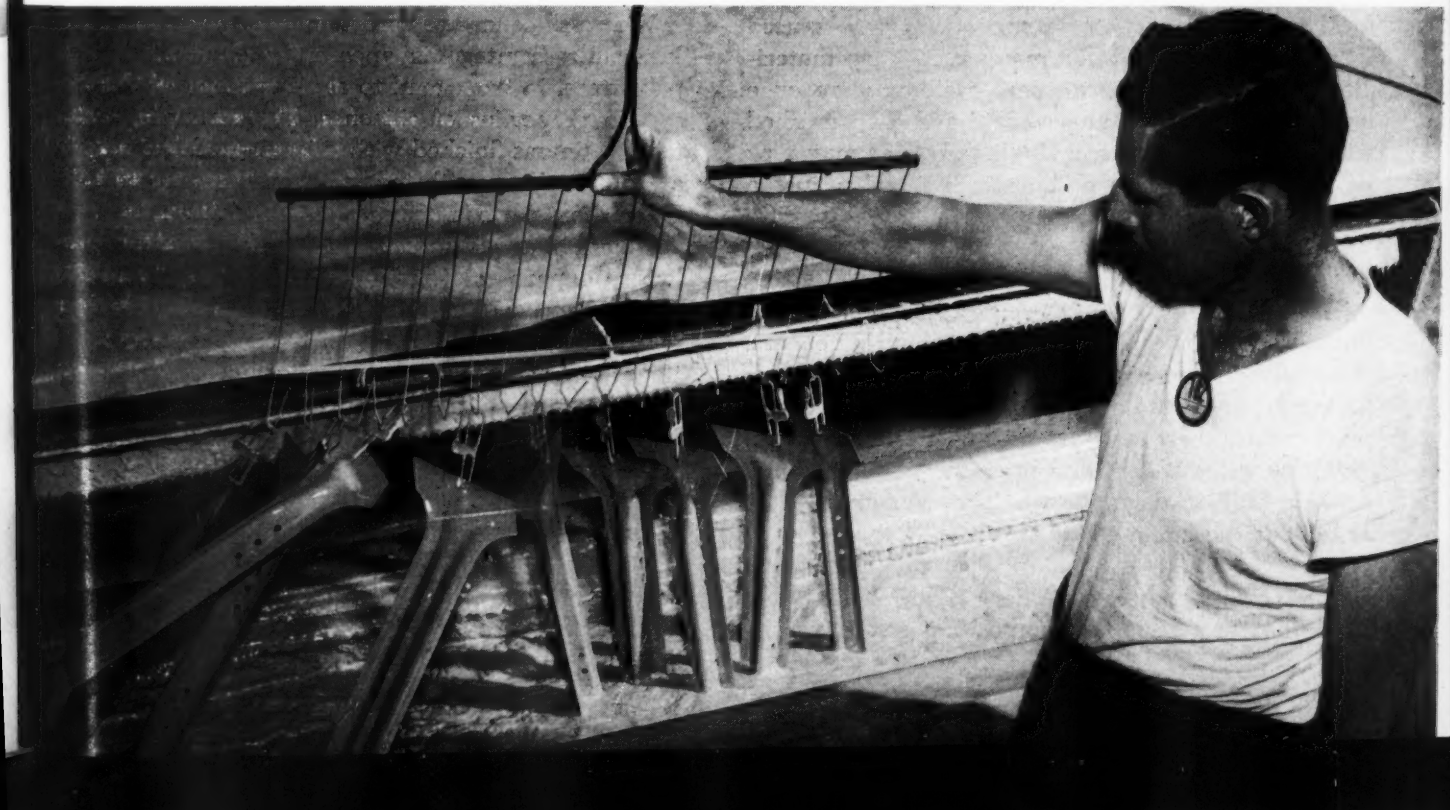
Because the properties of a resin are completely changed by polymerization, a solidified polyester coating may be completely impervious to the solvents with which it was initially thinned. Water-thinned polyesters, for example, become highly resistant to water once they are allowed to solidify.

Bake-On Enamels

From the industrial viewpoint, the most important polyester coatings are the so-called "synthetic" or "bake-on" enamels—not only because they can be used to produce extremely tough and durable finishes with many color effects, but because they can be rapidly and completely solidified by heating to temperatures of 250 to 400 F. However, since there is no such thing as a general-purpose polyester coating formulation, considerable care must be exercised in selecting finishing materials for various functional applications.

In finishing products made for similar types of steel, the following varieties of coating vehicles may be specified: (a) Automobile finish—85 percent alkyd modified with 15 percent melamine (for maximum surface hardness and weather resistance). This formulation requires baking the applied finish

MANY POLYESTER FINISHES CAN BE APPLIED BY SIMPLE DIPPING METHODS USING CONVENTIONAL TECHNIQUES.



at 275 F for 30 minutes. (b) Refrigerator finish—70 percent non-oxidizing alkyd modified with 30 percent urea-melamine resin (for maximum whiteness and adhesion). This formulation requires baking the applied finish at about 300 F for 45 minutes. (c) Washing machine finish—60 percent alkyd modified with 40 percent melamine resin (for maximum resistance to hot soap or detergent solutions). This formulation requires baking the applied finish at 300 F for 45 minutes.

Application Methods

Polyesters can be applied as a spray, brush, or dip coating with virtually all conventional types of finishing equipment. However, some special precautions are necessary to avoid difficulties and to obtain best results in certain circumstances.

For instance, where polyesters are applied with steam or heat spray equipment, it is necessary to anticipate that polymerized coating particles will eventually collect and clog gun nozzles. Resultant delays can be avoided simply by immersing the clogged nozzles in stripper solutions and making temporary use of alternate nozzles.

Similarly, a special effort should be made to clean containers and other facilities used in applying polyesters since these coating materials solidify inside; polymerized thermosets adhere strongly to many different surfaces and they can be removed only with great difficulty.

Mechanized knife, roller, and calendering facilities are especially practical for the application of polyester coatings because they are capable of handling viscous solutions. They can therefore save much of the time and trouble that might otherwise be required to thin out monomeric liquids with volatile solvents.

In addition to serving the decorative and functional purposes of conventional organic and inorganic finishing compounds, polyester coatings may be used to eliminate the need for many secondary materials. For example, where metal castings were once impregnated with sodium silicate and then finished with cellulose lacquers, a single polyester may now be used to permeate and coat castings in just a single operation.

Laminates

Polyesters are particularly useful in the production of laminates comprising layers of wood veneers, glass fabrics, and/or paper. Polyesters can simultaneously impregnate the sheets, serve as bonding media when the sheets are assembled and molded (with or without heat and pressure), and they can provide built-in decorative finishes which will last as long as the laminates themselves.

It is very unlikely that polyesters will replace ceramic coating materials. There is no reason to believe that any resinous composition can have the high heat resistance of porcelain-type enamels. However, bake-on polyester enamels are being used in place of ceramic coatings for many applications which do not require the high heat resistance of inorganic materials. For example, sheet metal street signs which once would have been porcelain-enameled are now being polyester-finished. The polyesters are not as expensive as raw materials, and they can be applied for less than half of the cost of porcelain-enameled signs for all practical purposes; polyester-finished materials can withstand rough treatment that would cause ceramic coatings to crack. It is relatively easy to stencil letters, numerals, and symbols on various surfaces where organic coating materials are employed.

In the manufacture of products like bathtubs and sinks, porcelain enamel finishes are still preferred because they are unaffected by a greater variety of solutions than any one polyester coating. However, some polyesters are able to resist powerful reagents —such as hydrofluoric acid—which will attack porcelain enamel coatings and cause them to deteriorate rapidly.

Silicone Modifiers

An announcement was recently made about what could easily be the most important polyester coating development of recent years. It involves the modification of alkyds with silicone resins. Silicones are the most chemically-inert plastics now in production. Besides being impervious to low and high temperatures that would cause other resinous materials to burn or crack, they can be converted into polymers with ceramic-like resistance to many common solutions. But, prior to the new development, they were not widely used as finishing materials because they apparently could not be combined with many of the plasticizers and pigments which are essential to many coating applications.

Where silicones are used to modify polyesters, the latter disadvantage is apparently eliminated. The polyesters, in turn, tend to acquire many of the desirable properties of silicones. For example, metal test specimens finished with silicone-modified alkyds are said to have withstood temperatures up to 1500 F for short periods of time without failure, to have retained high gloss and color stability after prolonged exposures to temperatures of 400 F and 500 F, to have shown creepage of less than ¼-inch after a 500-hour exposure to a 20 percent salt spray solution, to have been unaffected by 100 percent relative humidity at a constant temperature of 105 F following a 2000-hour exposure period, and to have had all the applicational advantages of the best polyester bake-on enamels.

One clear silicone-alkyd resin solution has been developed as a binder for aluminum pigments; the finished surface can tolerate temperatures of 1500 F. This coating is designed for outdoor chemical plants,

TYPICAL POLYESTER COATING MATERIALS AND APPLICATIONS

Resin Classification	Forms Available	Outstanding Properties	Application Methods	Typical Uses
PHTHALIC ALKYD				
Oxidizing types	Viscous solutions in organic solvents Viscous liquids Emulsions	Fast drying, great durability, excellent toughness, adhesion, gloss, and water resistance.	Spraying Dipping Brushing Roller coating Knife coating	Enamels for automobiles, gasoline pumps, farm machinery, coatings on food containers, metal signs, metal primers, printing inks, and marine paints; good for interior decoration.
Non-oxidizing types	Viscous solutions in organic solvents Viscous liquids	Durable, compatible plasticizers for cellulose nitrate, urea, and melamine-formaldehyde resins. Excellent retention of color and gloss.	Spraying Dipping Brushing Roller coating Knife coating	White baking enamels for refrigerators, stoves; automotive-type cellulose nitrate lacquers where outdoor durability is important.
Other types	Viscous solutions in organic solvents Viscous liquids Brittle solids	Faster drying than pure oxidizing types; better water and alkali resistance in phenolic types; greater hardness, lower outdoor durability than pure types.	Spraying Dipping Brushing Hot melt Roller coating Knife coating	Water-resistant primers, fast-drying architectural enamels; household enamels of moderate durability, color and color retention.
MALEIC ALKYD				
Varnish types	Hard, brittle solids	Soluble in varnish oils, giving varnishes with fast drying, good color, color retention, good hardness. Outdoor durability only fair.	Spraying Dipping Brushing Roller coating Knife coating	White architectural enamel vehicles, interior varnishes, metal decorating enamels, printing inks.
Lacquer types	Hard, brittle solids	Compatible with cellulose nitrate; very fast solvent release, pale color, good adhesion, and hardness	Spraying Knife coating Dipping	Cellulose nitrate wood and metal lacquers, furniture rubbing lacquers, cellulose nitrate sanding sealers.
SEBACIC AND OTHER HIGH MOLECULAR WEIGHT ALIPHATIC POLYBASIC ACID TYPES				
Lacquer types	Rubbery solids Viscous liquids Viscous solutions	Compatible with cellulose nitrate; give excellent flexibility, toughness, durability, and resistance to low temperatures.	Spraying Knife coating Dipping	Flexible lacquers for metal, wood, cloth. Particularly useful for raincoats, hospital sheeting, upholstery, and book cloth.
Polyvinyl chloride types	Viscous liquids	Compatible with polyvinyl chloride and copolymers; non-migrating, impart toughness, flexibility, and durability to vinyl compounds.	Calendering Knife coating Dipping	Flexible vinyl sheeting, cloth coating compositions, wire insulation compounds, automotive upholstery, theater and bar seats, shoes, and luggage coverings.

refineries, heaters, smoke stacks, and mufflers.

Still other modifications of commercial alkyds are made with styrene. The result is a finish with increased drying speed, great hardness, and improved resistance to water and alkalies. This class of alkyd also has great durability and color retention; its only failing is a comparatively slight loss in resistance to solvents. Among the non-phthalic alkyd resins modified with styrene which now commercially available are those specifically intended for baked finishes on metals. These are particularly good in adhesion and toughness.

The chart appearing above is a condensation of data on currently available polyester finishes. Their future is assured if only by the fact that current production is now 400 million pounds per year.

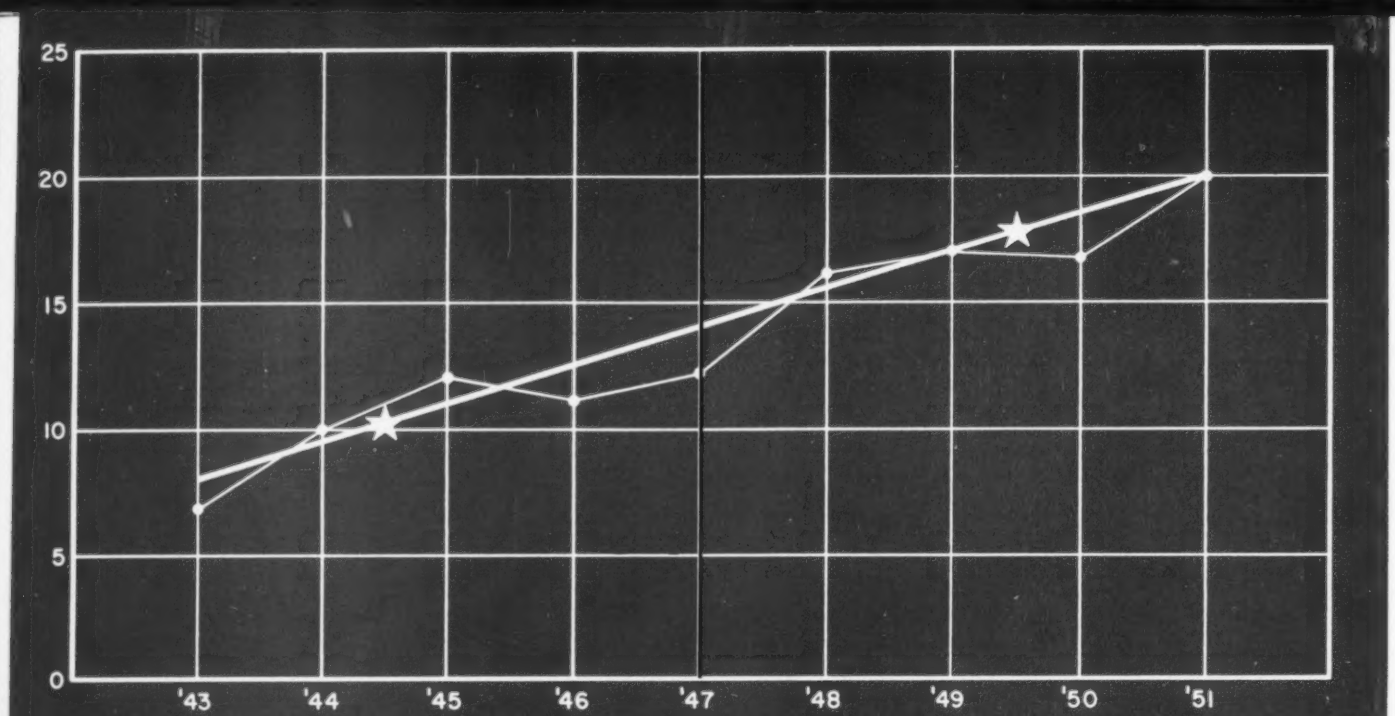
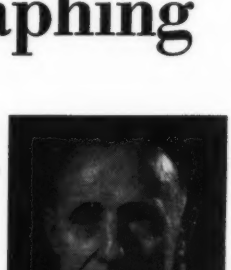


FIG. 1—HEAVY LINE THROUGH THE STARRED POINTS SHOWS TREND ACCURATELY, CAN BE DETERMINED QUICKLY.

Semiaveraging Makes Easy Graphing

ALLEN EVERETT
McKinsey and Company

MANY OF US must plot data graphically and must calculate "lines of best fit" to reveal correlations and trends. For instance, sales dollars in a plant-capacity study may be plotted by years; a trend line may be developed and projected as one of



Allen Everett has been concerned with manufacturing construction, taxation, and finance most of his professional life. He has been assistant to the president of Federal Light and Power and manager of planning for Henry L. Doherty & Co. (now the Cities Service Co.).

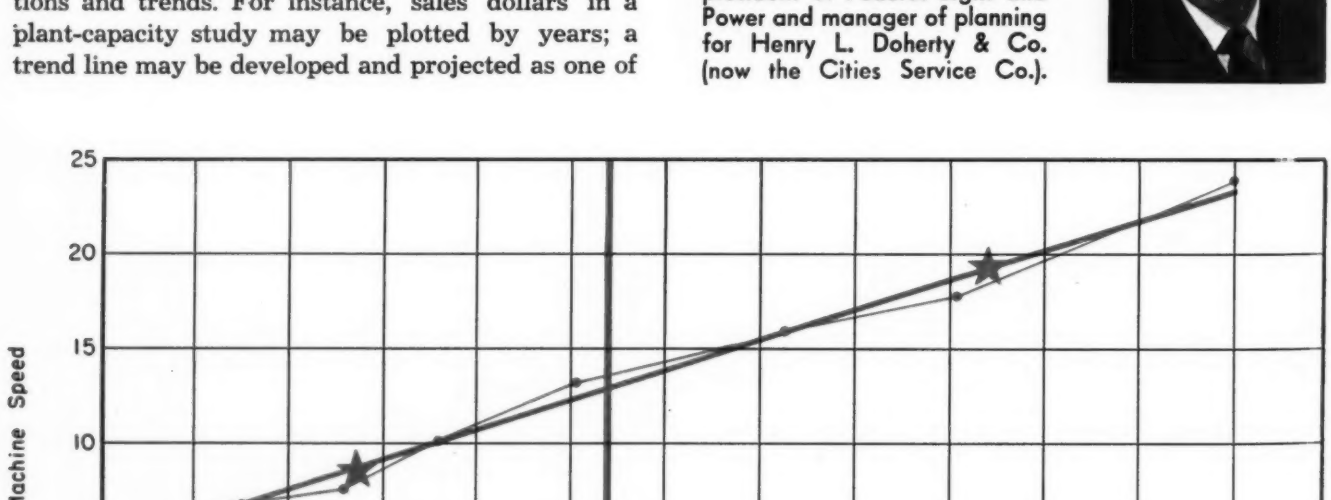


FIG. 2—SEMIAVERAGING TECHNIQUE GIVES REQUIRED LINE WITHOUT WAITING FOR INTERMEDIATE DATA.

the factors considered in estimating facilities that might be required in the future.

In another situation, a time-study engineer makes a limited series of observations (enough for an adequate sample) of time required to process an item when production time depends on some physical characteristic of the item such as cross-sectional area. He plots the series of production times against the cross-sectional areas of the sample, passes a "line of best fit" through the plotted points, and then reads the production time required for any intermediate area directly from the "line of best fit." He thus saves the time many observations would take.

Then there is the well-known "pricing" phase of a job evaluation study, where the average salary for each job grade is plotted. A smooth curve through these points determines ultimate salaries.

Statisticians usually calculate lines of best fit by means of the "sum of least squares" procedure. This method has high accuracy, but is somewhat complicated. A much simpler method that is accurate enough for most purposes is the "semiaverages" method. Tests reveal close correspondence between lines of best fit calculated by the two methods.

To apply the semiaverages method the graph is first divided into two sections by passing a vertical line through the "X" midpoint. Average "X" and "Y" midpoints are then determined for the left-hand and right-hand sections of the graph. These points are plotted and the straight line drawn through them is the "line of best fit."

The graph of Figure 1 shows how sales dollars of one firm varied over a nine-year period. Determining the trend (which is indicated by the line of best fit) will provide one factor for use in projecting future sales levels in planning plant capacities.

The year 1947 is the midpoint on the "X" scale. Therefore, average values of "X" and "Y" will be determined for each of the two sections on either side of this point. Values for the plotted points are set down thus:

X		Y	
1943		7	
1944		10	
1945		12	
1946		11	
1947	1945	12	52÷5=10.4
1947		12	
1948		16	
1949		17	
1950		17	
1951	1949	20	82÷5=16.4

By inspection, the average values of "X" for each of the two sections are respectively 1945 and 1949. Simple arithmetic gives corresponding average values for "Y" as shown. The line of best fit is then drawn through the points:

$$X = 1945; \quad Y = 10.4$$
$$X = 1949; \quad Y = 16.4$$

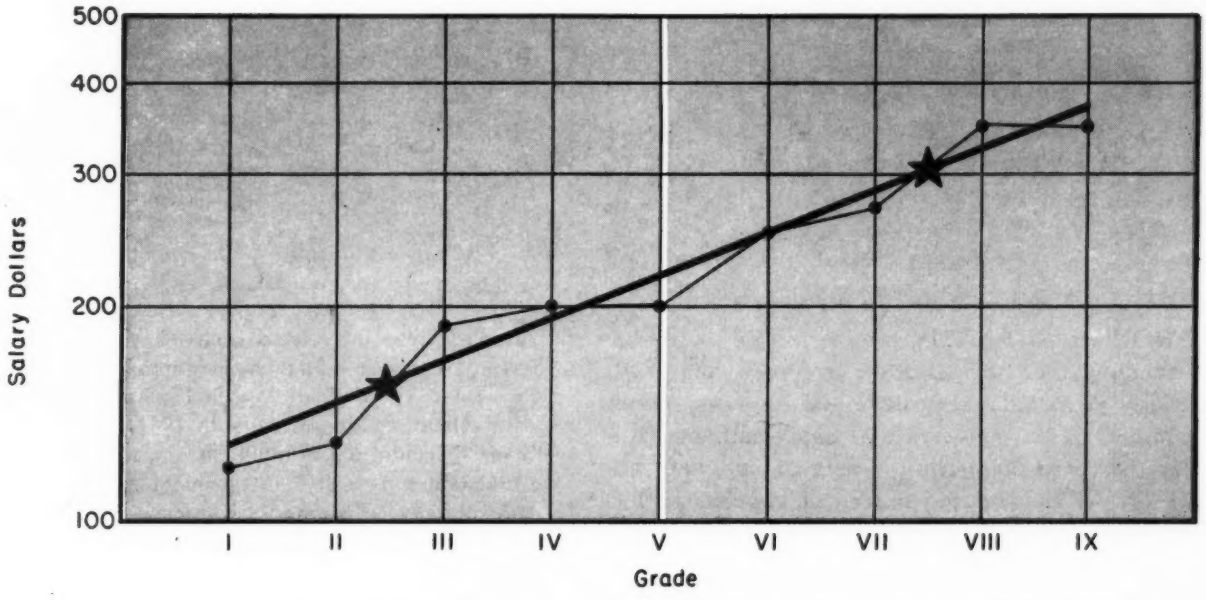
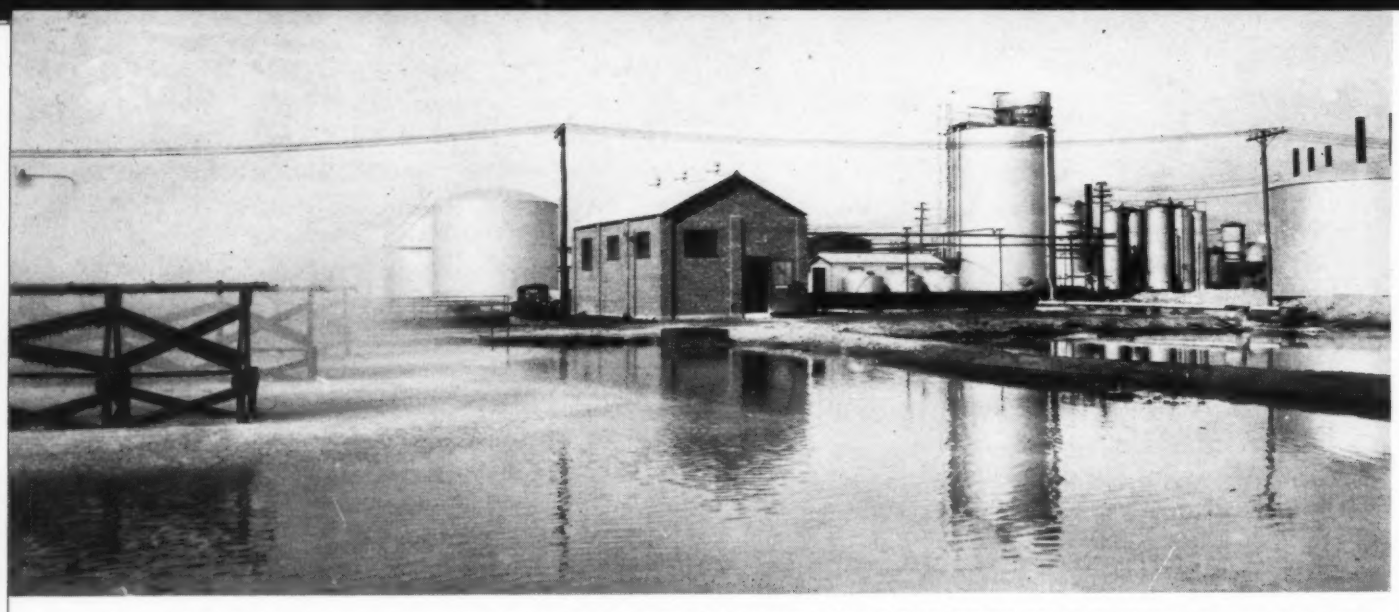


FIG. 3—TECHNIQUE CAN WORK ON NON-LINEAR CURVE; SEMILOG PAPER YIELDS LINEAR FUNCTION.

For the second example, assume that machine speed (as in that of a yarn-spinning frame) depends on tensile strength of material; this, in turn, is proportional to yarn size measured by cross-sectional area. For standard cost purposes, the time-study engineer wants to determine the machine speed (on which production depends) for all sizes of yarns

—*Continued on page 62*



COLD LIME TREATMENT IS USED TO REDUCE CALCIUM HARDNESS AND ALKALINITY IN OPEN CIRCULATING SYSTEMS.

Cooling Waters Require Careful Analysis and Treatment

DURANDO MILLER, Assistant Technical Manager, The Permutit Co.

Durando Miller graduated from the Yale School of Engineering, receiving a Bachelor's degree in Civil Engineering, and joined The Permutit Co. in 1938 as a member of the sales estimating department. In 1941, he was transferred to the technical department, serving there until his recent appointment as assistant technical manager. Author of numerous papers on the various aspects of sanitary engineering, Mr. Miller has served for three years as an instructor of industrial water treatment to classes in sanitary engineering at the NYU Graduate School of Engineering.

ALTHOUGH INDUSTRY requires more water for cooling than for all other purposes combined, for many years relatively little attention was given to cooling water conservation and treatment. Recently, however, dwindling supply or complete absence of any dependable source of cool water has fostered greatly increased study of cooling water problems. Once through systems, where the water makes only a single pass through the heat exchange equipment, now are employed only where large lakes, rivers, or the oceans provide unlimited cool water. Other locations combine circulating systems and proper treatment to permit maximum reuse of available supplies.

Circulating systems fall into two broad classifications—the open type where cooling is brought about by evaporation of a portion of the stream, and the closed type where cooling takes place in a radiator or other closed heat exchanger. In general, open systems are used for the larger requirements, such as process cooling in refineries and chemical plants, and condenser cooling in steam generating plants. Closed systems are applied more often for cooling jackets of diesel engines, compressors, and similar equipment.

With all types of cooling systems the circulating water must satisfy two general requirements. First, it must not unduly decrease the rate of transfer in the heat absorption equipment. This means a water is not suitable if it deposits excessive amounts of scale, plugs heat exchanger tubes with mud or silt, or coats metal surfaces with organic slimes. Second, it must not excessively corrode or erode any metallic part of the cooling system, or attack the wood of the cooling towers.

There is a degree of interrelation between these two considerations. For example, corrosion may result not only in a wasting away and eventual failure of heat exchanger tubes, but its products may contribute to plugging or scaling of other parts of the system. Incomplete scale formation will accelerate corrosion of surfaces having no scale.

Determining the best method of cooling water treatment for a specific application involves careful consideration of many factors including: (a) type of cooling system — whether once through, open circulating, or closed circulating, (b) materials of construction of the heat exchange equipment, (c) chemical and physical analyses of the available raw water, (d) cooling water flow rates, and (e) water temperatures to be expected in various parts of the cooling system. With open circulating systems, the type of heat dissipating medium — whether mechanical draft cooling tower, atmospheric cooling tower, or spray pond — will influence the design.

The part of the total flow requiring treatment varies greatly depending upon the type of system used. In once through systems the treatment, while usually not of an extensive nature, must be applied to the entire cooling water stream which may amount to many thousands of gallons per minute. Conversely, with closed systems the makeup will be only a fraction of one percent of the cooling water stream because losses due to leakage and possibly some evaporation from hot wells or expansion tanks are small. Makeup is normally a matter of a few hundred gallons per day.

With open circulating systems, the treatment problem is magnified. The concentrating effect of evaporation must be balanced by the deconcentrating effect of windage and blowdown to keep dissolved solids within desired limits. Thus, the makeup or flow to be treated in the open circulating system equals the sum of the evaporation, windage, and blowdown losses.

Evaporation is usually calculated as one percent of the circulating rate for each 10 F cooling taking place in the tower. Windage varies, depending upon the type of tower, running 0.2 percent or less for mechanical draft towers, about 0.5 to 1 percent for atmospheric towers, and 2 to 5 percent for spray ponds. Blowdown must be calculated for each application after the desired number of concentrations has been established.

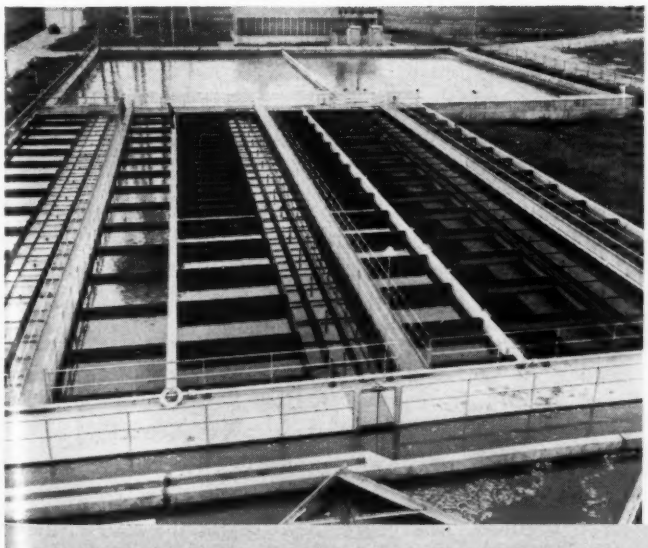
Clarification

Surface water supplies containing appreciable amounts of suspended matter should be clarified to prevent accumulations of mud and silt in heat exchanger tubes, pipelines, and cooling tower basins. One typical method of clarification is the use of sludge blanket precipitation type units.[1] With such equipment, coagulating chemicals and raw water are intimately mixed in the presence of previously formed precipitates. This results in the growth of large and tough floc particles which are readily separated from the water in the expanding area of the precipitation unit. Effluent turbidities of 2 to 5 ppm commonly are obtained, and water of this quality can be used directly in most cooling systems without filtration.

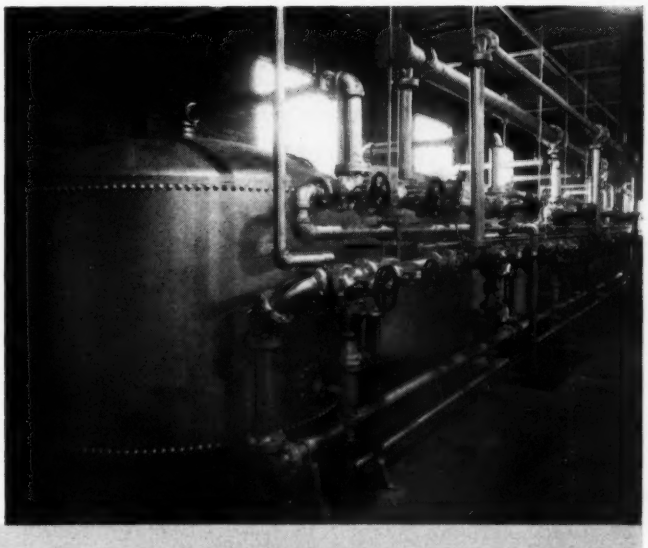
Prevention of Excessive Scaling

The most common type of scale found in heat exchange equipment is calcium carbonate, resulting from calcium bicarbonate naturally present in the cooling water breaking down under rising temperature. Waters high in sulfates may form calcium sulfate scale, but such cases are rare. Magnesium compounds seldom cause scale in cooling water systems.

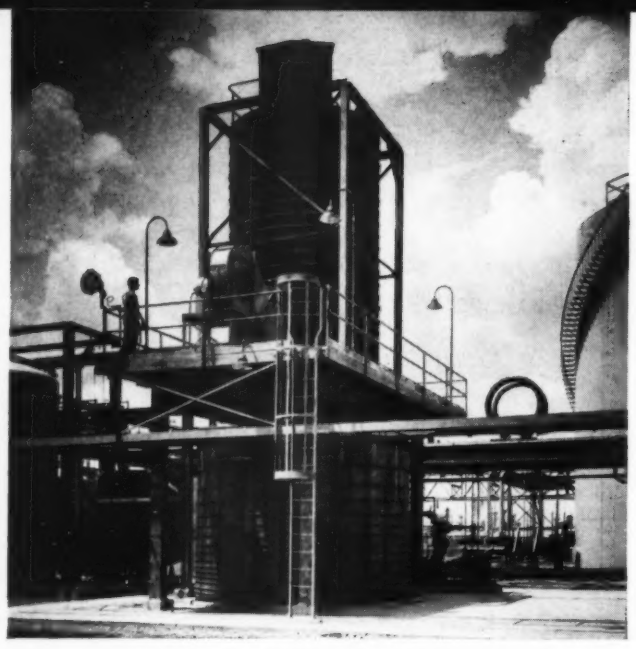
Dirt, organic slimes, oil, or corrosion products in the cooling water may serve as a binder for the scale-forming precipitates, thus aggravating conditions. Scale formation is usually more pronounced in the hotter parts of the heat exchange equipment.



SLUDGE BLANKET PRECIPITATION TYPE SOFTENERS ARE WIDELY EMPLOYED FOR COLD LIME TREATMENT.



THESE ZEOLITE SOFTENERS AND FILTERS PROCESS 38,500 GALLONS OF COOLING WATER IN TEN HOURS.



MANY DEMINERALIZING SYSTEMS USE DEGASIFIERS.

It is not uncommon to find clean metal, possibly undergoing corrosion, at the cooling water inlet side, but heavy scaling at the higher temperature outlet side of the exchanger.

When establishing treatment to limit scaling, it is first necessary to consider the construction of the heat exchanger system. If surfaces are of corrosion resistant alloys, it is often feasible to design for practically complete elimination of scale forming constituents. On the other hand, if ferrous heat exchange surfaces are used, complete elimination of scale may lead to serious corrosion, particularly in open circulating systems where the cooling water is saturated with oxygen as a result of its passage through the cooling tower.

With open circulating systems, the maximum concentrating effect theoretically possible can be determined from the recirculating rate, type of cooling tower, and cooling effect in the tower. From this information and the analysis of the raw makeup water, it is possible to calculate how high the scale forming constituents (primarily calcium hardness and bicarbonate alkalinity) would rise if no treatment were used. The question then is, will scale form or not? The best guide in this matter is the calcium carbonate saturation index, commonly called the Langelier index [2, 3, 4], which is a measure of the tendency for calcium carbonate to precipitate from a water under given conditions of calcium hardness, alkalinity, pH, temperature, and total dissolved solids.

Basically, a positive Langelier index indicates a tendency to deposit calcium carbonate scale, while a negative index indicates a tendency to dissolve a scale already laid down. Decrease in calcium hardness, alkalinity, temperature, or pH will lower the index, while decrease in total dissolved solids will slightly increase the index. However, a positive index does not provide a measure of the amount or rapidity of scale formation, since this is dependent upon the magnitude of the calcium and carbonate or bicarbonate content of the water. Furthermore, when calculating the Langelier index for open systems, it is the analysis of the circulating water that is used, not that of the treated makeup.

The pH requires special consideration because it does not concentrate as do calcium and alkalinity. Frequently the assumption is made that in the absence of phenolphthalein alkalinity, the pH of the water leaving the cooling tower will be 8.3, due to the complete elimination of free carbon dioxide in the tower. This assumption appears reasonably valid except where acid gases in the atmosphere cause lowering of the pH, or where the circulating water has a hardness very much lower than the alkalinity. In the latter instance part of the bicarbonates are converted to carbonates, resulting in phenolphthalein alkalinity and a pH which may be as high as 9.5.

Assuming that the concentrated cooling water has a positive index, reduction of calcium hardness, bicarbonate alkalinity, pH, or a combination of all three can be considered to decrease the index. Temperatures, of course, are fixed by the particular conditions of the cooling water system, and usually cannot be varied. Since the total dissolved solids content has a minor effect on the index, it is seldom used directly as a means of control.

One obvious method of reducing both calcium and alkalinity is by decreasing the number of concentrations in the cooling water through blowdown. This has the disadvantage of increasing the total makeup requirements and is seldom used as the only means of control. Also, it is possible for the index to remain positive no matter how much blowdown was employed. Moderate amounts of blowdown frequently are used, however, in conjunction with treatment of the makeup.

Cold Lime Treatment

Cold lime treatment is widely used for the reduction of calcium hardness and an equivalent amount of alkalinity thereby simultaneously lowering two of the factors contributing toward the positive index. The sludge blanket precipitation type of unit is commonly employed, and where the raw water contains suspended matter, it serves the double purpose of clarification and alkalinity reduction. Effluent with this method is normally stable with respect to calcium carbonate saturation, indicating that the Langelier index is only slightly positive at the treated water temperature. However, increased temperature plus the concentrating effect in the cooling system would result in an excessively positive index if no further treatment were applied. Therefore, acid is fed to the effluent for reduction of pH and alkalinity.

Determination of the correct acid dosage is a matter of judgment, depending upon the water

analysis and the number of concentrations taking place in the cooling system. In general, it is unwise to attempt to reduce alkalinity to less than about 10 ppm by acid. As an alternate, a polyphosphate may be used following lime treatment, especially if the water is not heated to a high temperature.

Residual calcium and alkalinity values will vary depending upon their relative amounts in the raw water, but ordinarily either calcium or alkalinity (in some instances both) can be reduced to about 35 ppm. Where the raw water alkalinity is appreciably higher than the calcium hardness, the effluent alkalinity will be higher than 35 ppm, but can be reduced as indicated by feeding acid. Where calcium hardness in the raw water exceeds the alkalinity, indicating the presence of calcium noncarbonate hardness, effluent calcium hardness will exceed 35 ppm unless soda ash is fed in addition to the lime. For economic reasons this is rarely done, since it is usually more practical to limit calcium content by increased blowdown.

With lime treatment, a calculated index in the range of plus 0.5 to plus 1.0 at the highest temperature in the system is usually satisfactory. Where the range of water temperatures is wide, say 30 F or more, it is advisable to consider careful adjustment of the pH of the circulating water to obtain a fairly constant index [5, 6], and thus uniform scaling over the entire temperature range. Where corrosion can be disregarded, the index can be maintained near zero, or even on the negative side, by reducing the alkalinity sufficiently with acid. This has the advantage of keeping cooling surfaces free from scale thereby sustaining heat transfer efficiency.

Zeolite Treatment

Clear, hard water supplies may be treated for control of scaling by sodium zeolite softening all or a portion of the water. Both calcium and magnesium hardness are exchanged for sodium as the water passes through the granular zeolite bed. This type of treatment has the advantage of simplicity since operation of the softener requires no chemical control, and where desired the regeneration procedure can be made fully automatic.

When using 100 percent zeolite softening, the hardness is reduced to a few ppm. Thus, even though the calculated index may be positive because of high alkalinity and pH, these high concentrations can be carried since the amount of hardness present is so small that very little scale can form. Complete zeolite softening should be used with discretion, however, for absence of scale may lead to corrosion.

Partial zeolite softening with hardwater bypass, plus acid feeding if required for reduction of alkalinity, is a simple and flexible method for preventing excessive scaling. With this treatment, leaving appreciable residual hardness in the water provides protection against corrosion of ferrous heat exchange surfaces. As with the lime treatment, control is normally by use of the Langelier index.

Waters having predominantly calcium noncarbonate hardness can be treated more economically by zeolite than by lime and soda softening. If the hardness is mostly in the form of calcium bicarbonate, lime softening will normally cost less. Where considerable magnesium hardness is also present, lime treatment is likely to be more economical because it removes calcium selectively, whereas zeolite removes both calcium and magnesium.

Acid Treatment

A third form of scale control consists of reduction of alkalinity by acid treatment. This process is applicable to moderate hardness, high alkalinity waters requiring no clarification. Treatment cost is often less than for softening, and equipment cost will definitely be less. However, since straight acid treatment increases the sulfates and does not reduce calcium, care should be taken that the circulating water does not contain calcium sulfate in excess of the solubility limit of about 1500 to 1800 ppm. Here again, the Langelier index serves as a guide to the control of the treatment.

Prevention of Corrosion

Since elimination of all scale may be undesirable where ferrous heat exchange surfaces are used, the "controlled scale" treatment is widely practiced for protection of this equipment. The aim of this procedure is to lay down a uniform, thin film of dense calcium carbonate scale in all parts of the system. It is low in cost, compared to other methods, and is actually a double barreled treatment because it also avoids excessive scale formation.

Any of the forms of treatment previously de-

VACUUM DEAERATORS HELP TO PREVENT CORROSION.

scribed, except complete zeolite softening, are applicable to the controlled scale method. It is undesirable, however, to attempt to carry either the calcium hardness or the alkalinity at a very low figure, as a small change in either one may upset the control. A number of test pieces of steel pipe should be maintained at various points in the cooling system, which can be inspected frequently to check the effectiveness of treatment.

Control usually is based upon the Langelier index, but it is by no means an infallible guide. Presence of organic inhibitors, oil, or excessive suspended matter may result in formation of porous scale giving little protection, or may even inhibit all scale formation leaving metal surfaces bare and subject to corrosive attack by the oxygen in the circulating water. Therefore, the marble test for calcium carbonate saturation sometimes is employed as a guide rather than the Langelier index. Although somewhat cumbersome and time consuming, the marble test reflects the effect of inhibitors on scaling tendencies.

Where ferrous surfaces must be kept entirely free from scale and at the same time be protected against corrosion, the use of chromate as an inhibitor frequently is practiced[7]. A concentration of about 300 to 500 ppm of sodium chromate maintained in the circulating water forms a uniform, thin barrier between the metal and the oxygen in the water. This treatment is also used in some plants having alloy heat exchange equipment, particularly where high salt concentrations are encountered. Chromate treatment is relatively expensive because of the high concentration required, particularly in open systems having a large percentage of makeup.

Since oxygen is the primary cause of corrosion, cold water deaeration using a vacuum deaerator[8] represents one straightforward approach to the problem. A vacuum of about 28 in. Hg is maintained within the deaerator, usually by multistage steam jet ejectors although for the smaller units a vacuum pump can be utilized. Oxygen is reduced to 0.25 to 0.50 ppm or less, depending upon water temperature, ejector capacity, and filling height. At these concentrations, corrosion rates are greatly reduced.

In open circulating systems, the aerating effect in the cooling tower saturates the water with oxygen, and therefore the vacuum deaerator must be designed to handle the entire circulating flow. Thus, the investment for the deaerator becomes appreciable for high circulating rates, but capacities of 5000 to 10,000 gpm are not uncommon. Operating costs usually compare favorably with other methods.

Sodium sulfite is commonly used following deaerating or open heaters in boiler plants to take up residual oxygen. However, the reaction between commercial sulfite and oxygen is slow at cool water temperatures, and it is not practical for cooling water deaeration. Recently, catalyzed forms of sodium sulfite have been developed which react rapidly with oxygen at cool temperatures. Cost appears to be the main limitation of this treatment, since the sulfite requirement is about 10 parts per part of oxygen. With low alkalinity raw waters, use of an alkali to raise pH also is indicated because oxygen corrosion proceeds more rapidly at low pH values. Usually, lime is recommended for this purpose because of its low cost and the fact that it also raises the calcium hardness.

Slime and Organic Matter

Chlorination is the most common method for controlling organic slimes which coat heat transfer surfaces and clog cooling towers. Feeding may be either continuous or in intermittent slugs, the latter often being favored since it results in less loss of chlorine by aeration in the tower. Sudden high concentrations also prevent algae or other organisms from developing a tolerance to the chlorine.

Copper sulfate has been used, and may be effective against certain strains of algae particularly resistant to chlorine. It is not lost through aeration in the tower, but its use is limited by the fact that the copper precipitates at pH values of 8.5 or over. Phenolic and quaternary ammonium compounds, which are not removed by aeration or precipitated at high pH, have been used with success in a number of instances.

Miscellaneous Chemical Treatments

Polyphosphates and glucosates, singly or in combination, are used in a number of cooling water installations, for prevention of both excessive scaling and corrosion. Satisfactory protection is reported in some applications, while in others results have not met expectations. There is evidence that the polyphosphates, used in conjunction with controlled scale treatment, permit somewhat greater ease of control by broadening the index range which may be carried without excessive scaling.

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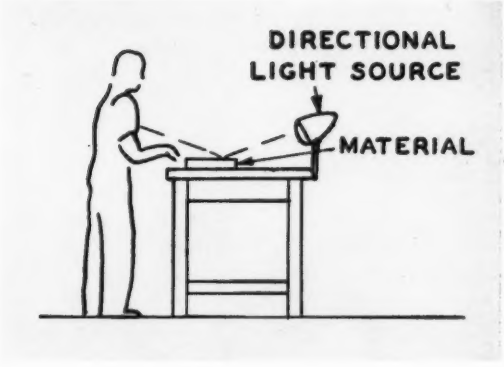


FIG. 1—A STRONG BEAM FROM A DIRECTIONAL SOURCE IS USED HERE TO DETECT FAULTY WELDS IN SMALL WIRES IN THIS INSPECTION PROCESS.

Lighting for Industrial Inspection

R. L. ZAHOUR and M. E. HASKINS, JR.
Westinghouse Electric Corporation

CAREFULLY ARRANGED LIGHTING of an industrial inspection area allows inspectors to see defects easily and quickly without eye discomfort. Three requirements govern the lighting of an inspection station. In general, there are eleven different methods of fulfilling these requirements.

The three requirements are: the light must be of the proper quality and quantity; the light must come from the right direction; and the light should render illumination of contrasting color. Aptly satisfied, these requirements will provide tailor-made illumination for any specific inspection task.

Surface characteristics of materials vary in color, finish (dull, glossy, opaque, or transparent), and shape. Hence, no general method of inspection lighting can be recommended for all cases. That's where the eleven different methods arise:

Narrow Beam

Narrow beam directional light: a strong beam of light from sources such as reflector lamps, Fig. 1. The lamp is mounted on the work bench and is aimed at the material so that the reflected beam is below eye

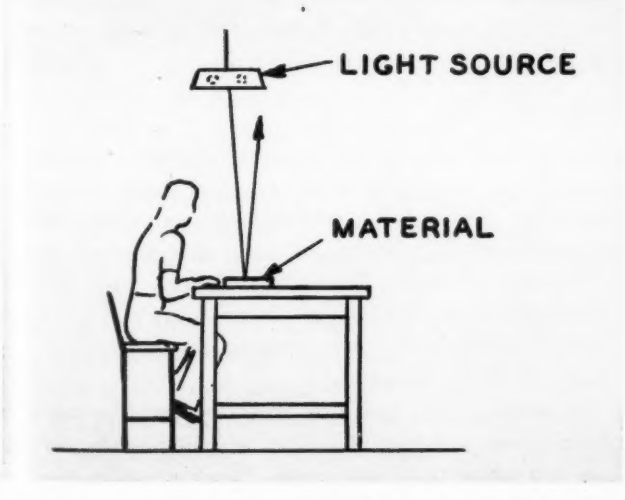
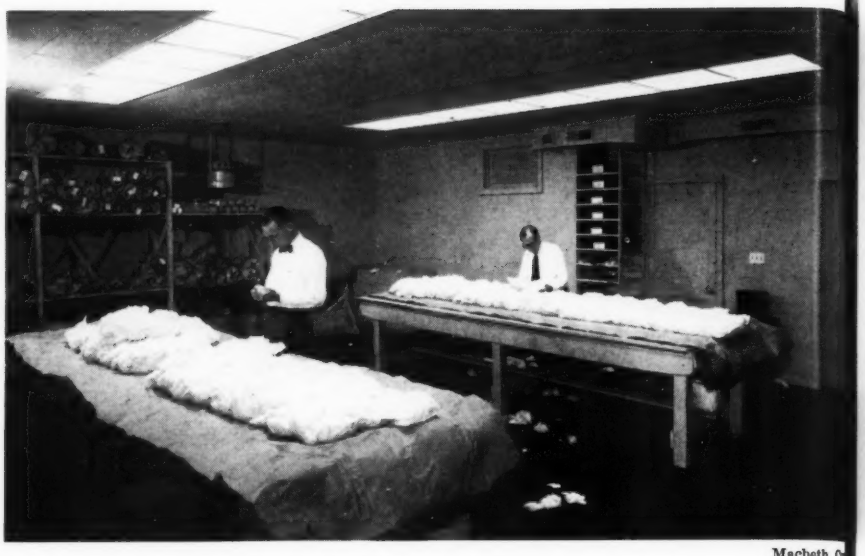


FIG. 2—INSPECTING STOCKINGS FOR FLAWS AND FOR MISMATCHED PAIRS UNDER SPREAD DIRECTIONAL LIGHT.

Macbeth Corp.



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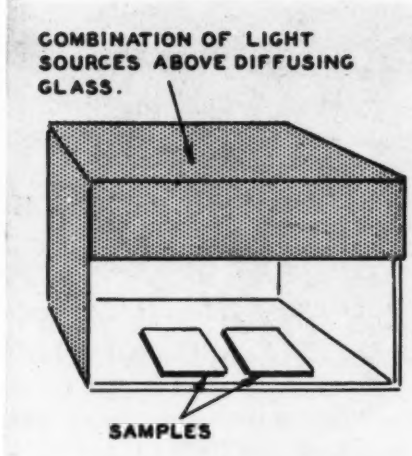


FIG. 3—OVERHEAD FIXTURES HAVE SELECTED COMBINATIONS OF LIGHT SOURCES SHINING THROUGH DIFFUSING PANELS TO GIVE CORRECT COLOR RENDITION FOR SPECIAL INSPECTION TASKS. INSTALLATION AT LEFT IS FOR COLOR MATCHING AND FOR DETECTING COLOR DIFFERENCES. COTTON CLASSING SHOWN ABOVE DEPENDS ON PROPER LIGHT QUALITY FOR ACCURATE APPRAISAL.

level. This method serves to detect breaks, flaws, or scratches in matte surfaces (unglazed tile or china) or blowholes in castings.

Diffused Source

Spread directional light: a diffused light source suspended over the inspection area to prevent reflection of the source from the material (Fig. 2). This method should provide 100 footcandles or more and should be employed when inspecting materials with light diffused or dark polished surfaces. Such situations occur in proofreading, detection of finger marks on dark enameled surfaces, and reading of instrument scales.

Diffused lighting: a large diffused source of low brightness located over the inspection area so that the reflection of the source is visible over the entire surface of the material. This scheme reveals darkened defects on light polished surfaces. It also shows specular faults on matte or dark materials, such as cuts and scratches on leather work, scribe marks on castings, punch marks on dull metal, or warps on glossy surfaces. Often, horizontal black stripes uniformly spaced on the luminous background serve as a method of detecting any specular non-uniformity in sheet-metal pieces laid flat on the inspection table.

Color contrasts and color matching: cabinet or luminaire equipped with sufficient sockets to permit combinations of fluorescent whites, colored lamps, or other sources, (Fig. 3).

Projected Image

Projected image: a beam of light is projected through a transparent plate supporting the work. The light beam is then optically transmitted through a system of mirrors, and finally is reflected onto a translucent screen. By this projection of light, the contours of small articles placed on the work plate are projected and are magnified several times, permitting close inspection.

Polarization: a luminous area covered by a polarizing sheet, serving as a light source and as support for the work to be analyzed. The inspector looks at the work through a sheet of glass or plastic polarizing

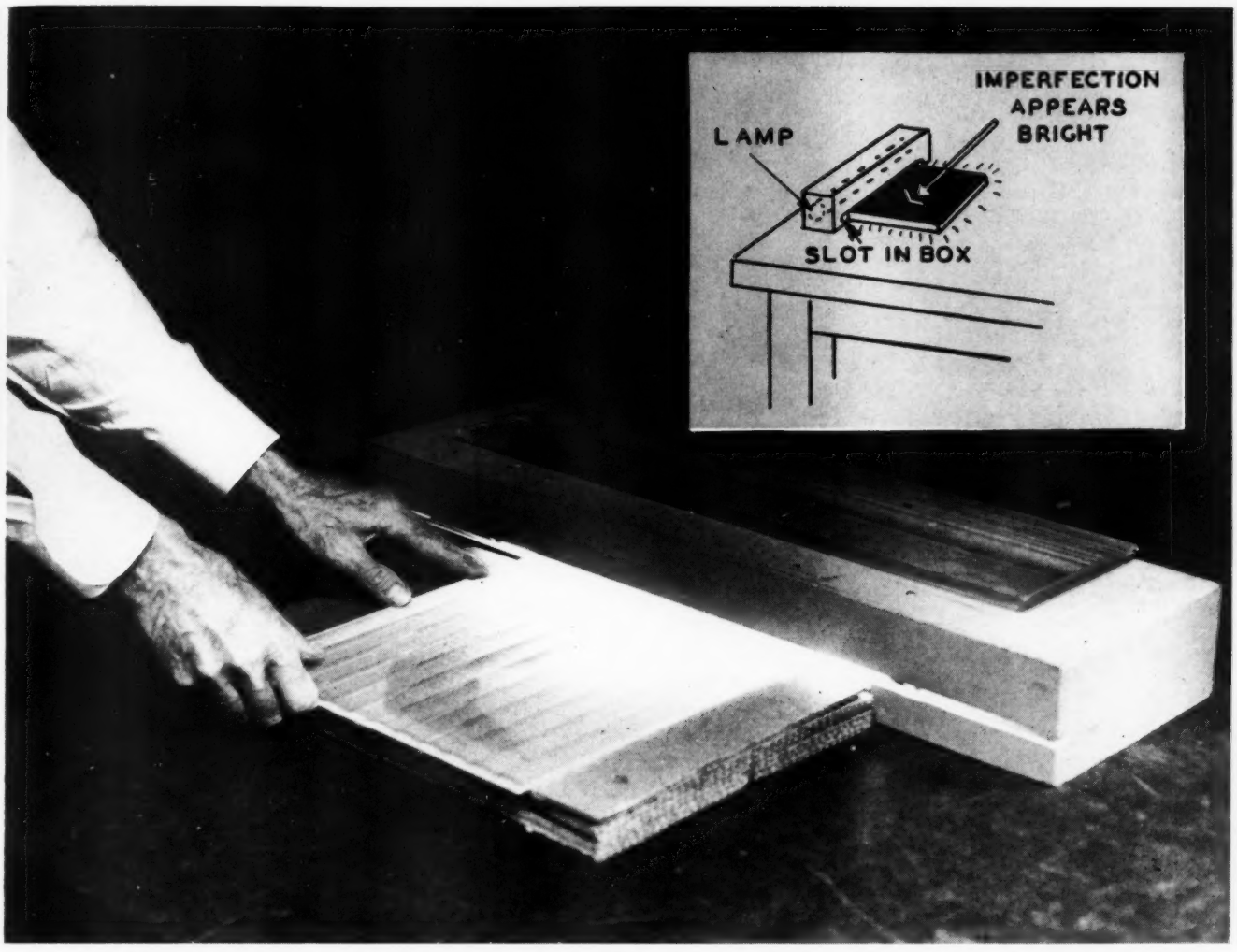


FIG. 4—EDGE LIGHTING IS USED TO INSPECT GLASS OR PLASTIC SHEETS FOR BUBBLES, CRACKS, AND SCRATCHES. INSET SKETCH SHOWS HOW AN IMPERFECTION WOULD SHOW UP AS A BRIGHT MARK IN THE MATERIAL UNDER INSPECTION.

material. Stresses or strains in transparent or translucent materials such as glass ware, lamp bulbs, or plain bottles show up in pattern forms when viewed by this polarizing method.

Edge Lighting

Edge lighting: a fluorescent lamp enclosed in a box with an open slit of width equal to the work, (Fig 4). This method is useful for detecting bubbles, cracks, or other flaws in sheet glass, plastics, or other transparent materials by placing the edge of the sheet against the slot opening in the box.

For detection of flaws in metals, the pieces are either powdered or immersed in liquid fluorescent materials. They are then cleaned to remove all fluorescent material except that which has lodged in the flaws. When the piece is examined under blacklight the fluorescent material in the cracks or flaws glows, showing the location and form of the flaws.

Blacklight: incandescent or mercury lamps equipped with suitable ultraviolet filters or blacklight fluorescent lamps. Sources are fitted with reflectors to direct the blacklight on the inspection area. This method has been found useful in detecting small cracks in castings or other metal parts, for inspecting eating utensils, for observing invisible laundry marks in crime detection work, and in many other similar applications.

Luminous panel background: a low-brightness diffused source located so that the material is between the inspector and source, (Fig. 5). This arrangement is suitable for detecting bubbles, chill-faults, cracks or similar defects in transparent or translucent objects such as glassware, bottles, or glass panes.

Magnification

Magnification method: a source consisting of small 6- or 8-watt fluorescent lamps, or Circline lamps shielded from the observer's eyes by a frame, (Fig. 6). In this method, the magnifying-lighting device can be adjusted to illuminate and magnify small pieces of work undergoing inspection.

Stroboscopic light: a rare gas vapor source such as a neon lamp which glows only at voltage peaks of alternating current, is used for this application. The

TABLE 1 — COLOR RENDITION FROM LAMPS

Light source	Effect of light on color						General rating	Lumens per watt
	Purple	Blue	Green	Yellow	Orange	Red		
75-watt incandescent	F	F+	G+	G+	G+	G+	G	15.4
500-watt incandescent	F	G	G+	VG	VG	G+	G+	19.8
1000-watt incandescent	F	G	G+	VG	VG	G++	G+	21.8
Soft white fluorescent	VG	G+	VG	VG	VG	VG	VG	48
DeLuxe warm white fluorescent	F++	F	G+	G+	G+	G+	G	50
Warm white fluorescent	G	F	G	G	G	G	G	63
White fluorescent	G++	G	G+	G+	G+	G+	G+	63
DeLuxe cool white fluorescent	VG	VG	VG	VG	VG	VG	VG	48
Cool white fluorescent	VG	VG	VG	G++	VG	G	G++	60
Daylight fluorescent	VG+	VG+	VG+	VG+	VG+	F	VG	53.5
E-HI mercury	G	F+	G	F+	F+	F	F+	50
J-HI fluorescent mercury	G	F+	G+	F+	F++	G+	G	47.5

VG = Very good; G = Good; F = Fair.
No source of "white" light is considered poor.

Rohm & Haas

FIG. 5 — PICKLED PELTS ARE EXAMINED FOR IMPERFECTIONS AGAINST A LUMINOUS PANEL BACKGROUND.

frequency is varied by control equipment. When the light is aimed at rotating or reciprocating machinery and the frequency of the lamp source is synchronized with the rotation frequency of the machinery, motion will appear to be stopped. Under this condition, vibrations or stresses may be observed.

Color Matching

If illumination of north skylight quality is desired for color matching, a combination of three 40-watt daylight fluorescent, two 20-watt blue fluorescent, and four 25-watt silver bowl incandescent lamps is installed in the upper part of the cabinet or in ceiling fixtures. Samples for color matching are placed side-by-side on the floor of the box for observation.

To select a suitable fluorescent white lamp to illuminate a color or group of colors with best color rendition, a cabinet can be fitted with one 20-watt fluorescent lamp of each of the seven whites: daylight, cool white, deluxe cool white, white, warm white, and deluxe warm white. A 60-watt incandescent lamp can be included for comparison purposes. Table 1 may be used as a guide in predetermining the color rendition obtained. By switching from one lamp to another, a suitable lamp or a combination of lamps may be selected after observing the effect of the illumination.

Where the surface inspection requires detection of color differences, different colored fluorescent lamps may be used in a cabinet or luminaire to determine a desired inspection light source. For example, a plated article may have discoloration spots or blemishes slightly different in color from that of the plating. One light source may not reveal this fault, while a source of another color may distinctly show a wide contrast between the plated and unplated area.

Analysis Methods

These eleven methods or variations will solve any inspection area lighting problems. They give an idea of what is available in the way of technique. When applying them, a brief set of rules can be used: Determine the physical properties of the material: surface (matte, glossy, transparent, translucent, combination); color (fixed or subject to change from period to period); shape (plane or three dimensional); size (size of defect to be detected); and location (position at which detail will be inspected).

Next, check background of detail to be inspected:

FIG. 6—MAGNIFYING AND LIGHTING ARE COMBINED IN ONE FIXTURE FOR EASY INSPECTION OF SMALL ITEMS.

contrast (difference in brightness between defect and immediate background); brightness (reflection factors of all background surfaces); and color (the dominant color of the immediate background and of the surrounding environment on which eyes rest).

Then seeing conditions required must be analyzed: contrast (brightness and color contrast); shadows (important or not necessary); time (limits of time for inspecting and for seeing); and detail (exact determination of fault to be detected).

Determine the illumination required to provide desired seeing conditions: quantity (footcandles for best visibility, see Illuminating Engineering Society Handbook); quality (diffused or directional light, position, maximum brightness and color quality of source); and absence of direct and reflected glare.

While these methods and analyses serve as a guide in arriving at a satisfactory solution, further study is needed many times. The services of a lighting specialist experienced in optics and in the behavior of light quality can be of great help.

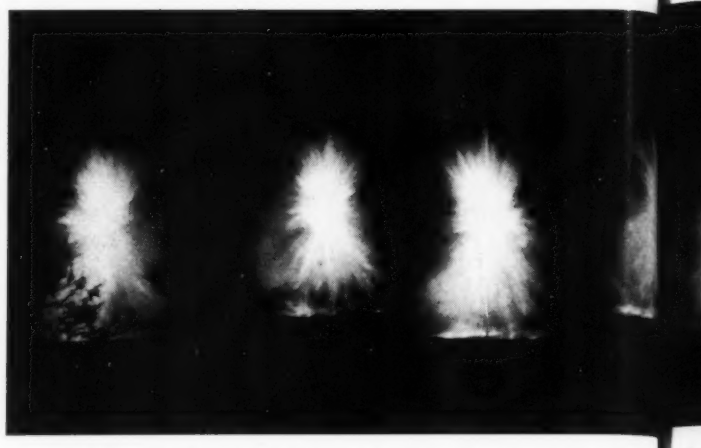
More Fluorescents For Street Lighting

THOUGH FLUORESCENT street lighting is now only three years old, it is now predicted that every major city in the country will have an installation of the giant fluorescent fixtures within ten years. Such is the view of C. K. Fulton, of General Electric's Lighting and Rectifier Department. Nearly 1000 fixtures are now installed or on order.

The largest present installation is the 77-unit group on Seattle's Alaskan Way viaduct. The first major application was in Detroit; the lights went into service there November 3, 1950. Other cities using the fluorescents for street lighting include St. Louis, Mo., Redwood City Calif., and Schenectady, N. Y.

Hercules Powder

PANCAKE CHARGES OF DYNAMITE, PLACED ON FLAT-TOPPED STAKES, ARE USED FOR PATTERN SHOOTING.



NIGHT PHOTOGRAPH OF A PATTERN SHOT USED IN SEISMIC

Explosives are Versatile

CE exclusive

C. H. CORDIE

Chemical Engineer

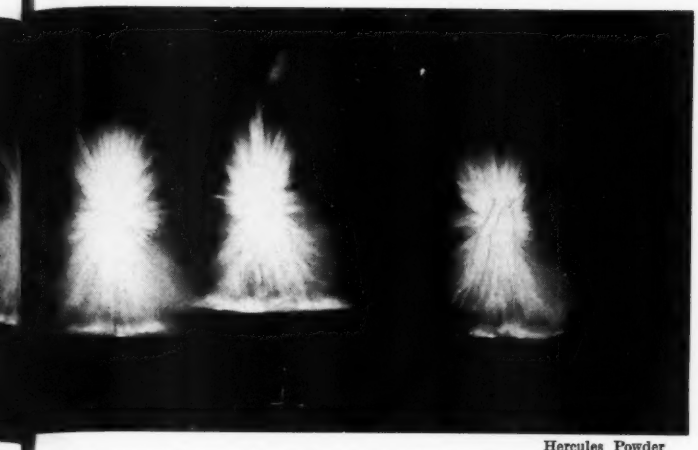
Cornell H. Cordie, a Penn State graduate, was associated with Hercules Powder Company for 30 years. As general superintendent of Aetna Explosives Co., he joined Hercules in 1921 when Aetna was purchased.

In 1934 he was named manager of explosives development, a position he held until retirement in 1951. In addition to research for and development of commercial explosives, his responsibilities included testing explosives for special uses, developing caps and detonators, and procuring patents. He is a past chairman of the technical committee of the Institute of Makers of Explosives and a member of the American Institute of Chemical Engineers.

WITHOUT EXPLOSIVES it would be impossible to construct tunnels and dams, blast out new highways, or carry on mining operations on the scale demanded by modern American industrial life. Although these projects consume the bulk of our dynamite production, many lesser known applications have been developed as a result of the versatility of explosives as a power source — a mobile power which can be brought into action in remote areas far from great industrial centers.

One of the most important of these lesser known uses for explosives is their application in geophysical or seismic prospecting for oil deposits. In the search for oil, explosives were first used about 1925 and their consumption has continuously increased to more than 50 million pounds in 1952.

In seismic work the detonation of explosive charges, usually 25 pounds or less, is used to produce vibrations in the earth which are recorded on a seismograph. The explosives are shot in drill-holes ranging in depth from 50 to more than 500 feet. Practically all of this work is now done by



Hercules Powder

EXPLORATION. NOTE STAKE WHICH HELD CENTER CHARGE.

measuring the time and amplitude of the vibration waves reflected from the various strata far below the shot point. The vibrations are detected by a number of geophones placed on the surface in a line starting fairly close to the shot point. The geophones convert the vibrations to electrical energy for transmission by wires to the recording instruments installed in a truck. The records obtained from a number of shots are then used to draw an accurate profile map of the strata for a mile or more underneath the shots. The map is used to estimate the chances of striking oil, and to select the likeliest spots for drilling.

Explosives for seismic work in drill-holes must have a high degree of water-resistance and must be capable of exploding at a high rate of detonation after prolonged exposure under heavy heads of water. They must be packed in extremely stiff cartridges, since they frequently are forced to the bottom of the shot holes through heavy mud. The cartridges — usually 2¼ inches in diameter, 24 inches long, and weighing 5 pounds each — are provided with a means for coupling two or more end-to-end to form a rigid column that will withstand the rough treatment of being pushed down the hole. The explosive in these cartridges is usually a specially designed 60 percent gelatin dynamite. The electric blasting caps also are specially designed to eliminate a time lag between the breaking of the cap's bridge wire, by passage of the firing current, and detonation of the charge. Seismic work meaures time in fractions of milliseconds.

Seismic Pattern Shooting

The so-called "pattern shooting" of explosives in seismic exploration recently has been developed and is being used by a number of crews. Basically this system requires a number of flat, circular (pancake) charges of high velocity explosive suspended in a pattern above the ground and in a horizontal plane. Seven, thirteen, or nineteen shot-points are normally used in a hexagonal pattern, with one point in the center. The charges are set from 15 to 85 feet apart, and are placed about 10 feet above the ground on flat-topped expendable stakes. The simultaneous detonation of all of these charges within one ten-thousandths of a second produces a flat seismic wave front of low amplitude over the entire area of the pattern, and delivers the shock into the earth. The vibrations in the earth are detected and recorded by standard seismic equipment.

Since no drilling equipment is needed, pattern shooting provides the advantages of speed and economy over the more usual method of shooting in fairly deep well-holes. In many locations, however, the shock of above-ground explosions causes disturbance to buildings and live stock — even at considerable distance. To avoid this, much of the pattern shooting is now being done with shallow, pattern-arranged drill-holes about 15 feet deep.

Submarine Prospecting

During the last ten or fifteen years the seismic method has been increasingly used in prospecting for oil in the Gulf of Mexico, off the California coast, and in coastal waters in other parts of the world. In the Gulf, the explosive is usually a single large cartridge weighing 10 to 50 pounds. It is chuted into the water from the end of a moving seismograph boat and exploded electrically after the boat has progressed to a safe distance and the explosive has sunk to the desired distance (about 6 feet) under the surface. The geophones are generally lowered to the bottom, and the vibrations are picked up and recorded much as in land operations.

In seismic work off the coast of California, the crews use explosives which have a much lower rate of detonation than those used on land or in the Gulf of Mexico. While the vibrations caused by these slower explosives do not penetrate as deep under the ocean floor as those from explosives used elsewhere,

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WORKMEN DRILL SHOT-HOLES AND PLACE DYNAMITE CHARGES DURING ACCELERATED SETTLEMENT PROJECT.

Hercules Powder

CARTRIDGES FOR A SEISMIC SHOT ARE COUPLED TOGETHER TO FORM A RIGID COLUMN FOR LOADING.

Hercules Powder

DURING THE SHOT, THE OPERATOR COMMUNICATES WITH THE RECORDING TRUCK (CENTER) BY TELEPHONE.

the results are satisfactory. The explosive charges, weighing about 50 pounds, are loaded into thin metal cans and are suspended from balloons at a depth of 6 feet under the water's surface. The shots are fired electrically from a surface craft.

At one time, divers loaded the seismic charges into holes "jetted" into the mud on the ocean floor. Jetting consisted of directing a high-pressure jet of water or air into the mud ahead of the explosive cartridge to push it to the desired depth.

Shooting Oil and Gas Wells

Explosives have been used for many years to increase the production of oil and gas wells by cracking the rock in the wells. In the past, liquid nitroglycerine has been the chief explosive used for this purpose. Now, however, many shooters add other explosives to the liquid nitroglycerine in order to reduce its sensitivity to accidental explosion from friction or impact, to lower its freezing point, and to reduce its rate of detonation. Much of the liquid nitroglycerine also has been replaced by Solidified N. G. or Blasting Gelatin, which consists of nitroglycerine gelatinized by the addition of a small amount of nitrocellulose.

Oil wells are being drilled deeper and deeper—some exceeding 15,000 feet—with the result that the temperature through the lower parts of the well is so high that nitroglycerine is liable to decompose and explode while being loaded into the well, or at least before the shot arrangements have been completed. To meet this condition, solid mixtures containing explosives which are more heat-stable than nitroglycerine have been developed.

One of the most spectacular uses of explosives is the practice of extinguishing burning oil or gas wells, where the fire is literally "blown out" by the explosion of a considerable quantity of dynamite at a point as close to the base of the flame as it is possible to reach without undue hazard.

Fill Settlement Work

When building roads, it is often necessary to lay a grade through a swamp. If the muck and [illegible] material in the swamp are not too deep, excavation can usually be accomplished by mechanical equipment. Often, however, the muck is so deep or [illegible] such a consistency that mechanical removal is impracticable or uneconomical. For such locations, engineers have developed a method which consists of placing the granular filling material, crushed stone or gravel, on the surface of the swamp to a height needed to reach the firm bottom of the swamp after the fill has settled. The higher density of the fill material produces a slow natural settlement, displacing the muck to the sides.

To accelerate and complete this settlement, charges of explosives, usually gelatin or semi-gelatin dynar ite, are placed in the muck under the fill material about 10 or 12 feet apart. The charges may weigh from 50 to 200 pounds apiece and are all fired simultaneously, causing the muck to be pushed off to the sides of the fill and allowing the fill material to settle to the swamp bottom. In addition to new

roads, accelerated fill settlement has been successfully used for repairing old roads on which the original fill had not been properly settled.

Sometimes a wide ditch is previously blasted along each side of the fill to facilitate movement of the muck. For the most economical results, the ground to be ditched should be wet, in which case the blasting can be done by "propagation". In this method, a series of 1¼ x 8 inch cartridges are placed vertically in the ground along the desired line of the ditch. The spacing between cartridges is normally 15 to 24 inches, and the depth of the holes is 2 to 2½ feet, depending upon the final depth of the ditch.

When the dynamite in the end hole is exploded by means of a blasting cap, the force of the shock traveling through the wet earth detonates the adjacent cartridge. Each remaining cartridge is then consecutively exploded by propagation. Although ditches more than a mile in length have been blasted at one time by this method, the usual length for one shot is 500 feet or less. Propagated ditching requires wet ground and a special nitroglycerine dynamite called Ditching Dynamite. In dry soils the explosive is loaded in much the same way except that an electric blasting cap is placed in each cartridge and all cartridges are shot simultaneously.

Delay Electric Blasting Caps

For many years, particularly in blasting tunnels through rock, engineers have used electric caps having an internal fuse which delays detonation of the cap for a few seconds after the firing current has been applied. A series of these caps, known as delay electric blasting caps, will provide firing delays ranging from zero to around 15 seconds at about one second intervals.

In blasting a vertical face of rock in a tunnel, explosives are usually loaded into a number of holes arranged roughly in concentric circles around one or more central holes, called cut holes. Instantaneous or non-delay caps are used to detonate explosives in the cut holes, first delay (1 second) caps for the circles of shot-holes adjacent to the cut holes, and successively longer delays for the holes in the other circles. Firing current is applied to all caps simultaneously. The cut holes, which explode instantaneously, blast the rock from the center of the face, thus relieving the burden on the explosive in the adjacent circle of holes. The explosive in this circle detonates next, relieving the burden on the holes in the next circle, and so on. This method permits the entire face to be blasted out at one time with less explosive and with much less shock damage than if all the holes were blasted simultaneously.

During the last ten years, a new type of delay cap called the Short Period or Millisecond delay has been developed to provide 20 to 40 millisecond intervals between adjacent periods. In one manufacturer's series, the No. 1 cap explodes about 25 milliseconds after the application of firing current. The series proceeds with gradually increasing time increments to 400 milliseconds for the 12th delay.

This type of cap was developed primarily to reduce vibrations from blasting in quarries, open-pit mines, and similar operations located fairly close to inhabited areas. They can be used to advantage in any number of patterns, but a simple example is a shot consisting of a row of 12 vertical holes along the top of a quarry face, drilled some distance back of the face. If the explosives in all 12 holes were shot simultaneously, the vibrations produced would be much greater than if a series of 12 shots followed one another in rapid succession.

The reduced vibration resulting from the use of short period delay caps has been conclusively established by many seismograph records. To quote from one report, "the intervals between these delays are so small that before the broken mass of rock (from the first hole) has a chance to topple over, adjacent holes have detonated, not as in an instantaneous-cap shot, but following one another in rapid succession. Thus, there are several causes for reduced vibration: a reduction in the number of simultaneously detonating holes; the charges that detonate first perform a relieving action for adjacent charges by loosening the burden on them; and the different sections of broken material, held in suspension but slowly moving, act in opposition to each other, and this retards, cushions, and seemingly absorbs vibration waves."

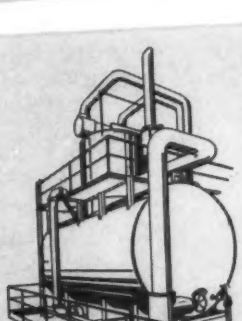
Short-period delay caps have attained wide-spread use not only because they reduce vibration, but also because experience has shown that they improve the fragmentation of the blasted rock and in general improve the efficiency of the whole operation.

When the great variety of applications for explosives are considered, it is easy to understand why engineers consider them as truly versatile tools. It is safe to predict that many new applications will be added to the already lengthy list.

Hercules Powder

RELIEF DITCHES, BLASTED OUT ALONG THE FILL, FACILITATE MOVEMENT OF MUCK DURING SETTLEMENT.

This 10,000 lb. per hour PACKAGED DEAERATING HEATER



has the same design and performance characteristics as this 1,000,000 lb. per hour central station heater

Unlike the central station plant, the small steam generating plant must often function with little operating attention. That is the very reason why this plant should insist on equipment that will give dependable, fool-proof, 24-hour-a-day service with a very minimum amount of maintenance attention.

A well-designed deaerating heater in this plant protects the boilers, feedwater heaters, and condensate return lines . . . it must indeed be a rugged, dependable watchdog.

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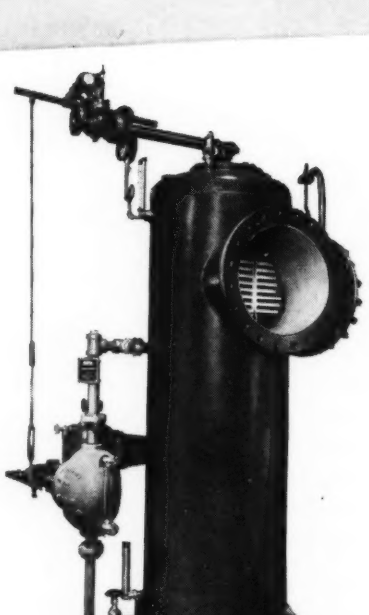

FEATURES OF GRAVER PACKAGED DEAERATING HEATERS

Spray or Spray-Tray Design . . . as best suited for particular plant conditions

Corrosion-Resistant Construction . . . vent condenser, spray valves and tray cubes of stainless steel

Internal Vent Condenser . . . avoids tube bundle cleaning, reduces weight and headroom

Self-Adjusting Spray Valves . . . highest efficiency at all loads, accessible from exterior

Tray Cubes . . . rugged construction, light weight, convenient size

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the Range Finder

DR. GERALD J. MATCHETT

Director

National Center of Dynamic Equipment Policy

and

Department of Business and Economics

Illinois Institute of Technology

EVENTS SURROUNDING the fire at General Motors Livonia plant are now generally agreed upon by observers. This fire, one of the most destructive single fires of all times—not of life but of industrial equipment—has led top management everywhere to ask, "Can this happen to us?" Unfortunately, the answer is almost invariably "Yes." As a consequence, consulting engineers are being called upon to study and evaluate existing fire prevention facilities.

Fireproof Building

The General Motors plant was a new, modern building constructed of concrete and steel and covering about 30 acres under one roof. It was assumed to be virtually fireproof. The fire was caused by sparks of an oxy-acetylene welding and cutting torch falling on a metal drip pan. The pan was covered with drippings from parts that had been dipped in a highly inflammable rust inhibitor. Despite the immediate use of fire extinguishers, the fire in the pan ignited residual oily deposits on the ceiling.

When the metal drip pan warped from heat, flaming liquid dripped to the floor below and ignited the wood block overlay. Meanwhile, the high temperature caused the panels of the steel-deck roof to buckle and separate. Roofing tar fell onto the fire underneath, adding more fuel. This combination—the burning wood block floor, the buckling steel roof panels, and falling roofing tar—extended until practically the entire plant was consumed. Dense black smoke prevented firemen and firefighting equipment from getting near the fire once it was underway.

Tragedy of Livonia

The tragedy of Livonia is two-fold. First, it has become quite clear that the fire was preventable. It was a costly and unnecessary occurrence. Fire would not have occurred had flames, sparks, and hot metal been kept from contact with flammable materials. A few inexpensive, well-placed, safeguards could have made it impossible for sparks to fall into the drip pan.

Secondly, once the fire had started, it might have been controlled if exclusive reliance had not been placed upon the fire extinguishers located around the plant. Its control could have been assured by the addition of relatively inexpensive fire-fighting techniques and devices.

Of course, any analysis of fire prevention and control must weigh the added costs of greater safety against the value gained by reducing the risk and damage of fire. An important part of any fire protection program is to take steps to eliminate sources of fire. More attention can be paid to the design of plant facilities and layout with the specific intention of removing fire causes. In the case of the Livonia plant, for example, there were no explosions—a fact that undoubtedly contributed to the small loss of life. Combustible liquids were stored in deep tanks buried under the building. These tanks did not catch fire or explode. A plant should be designed so that combustible material is removed from areas where ignition is a hazard.

Preventive Measures

An intensive training program can be maintained to train employees and supervisors in preventive measures. There is no substitute for good housekeeping; a contributing factor in the General Motors fire was the deposits of oily matter accumulated on the ceiling.

Qualified persons can be hired to rigorously enforce all precautionary rules and to develop additional regulations that seem advisable. When any particularly hazardous equipment is used, these people should examine the work site and enforce

any precautions they might think were necessary.

In theory, it should be possible to make a plant "fireproof" against internal fires. Each additional precaution costs money, and there comes a point beyond which the added safety may not warrant the money spent to accomplish it. Furthermore, periodic fires may occur from external factors beyond the control of management.

Preventive measures, therefore, are not alone the answer. However, the cost of an ounce of prevention should be carefully weighed against the price of the pound of cure.

Loss Minimization

Important parts of any fire protection program are the steps to minimize losses once a fire has started. If a general principle can be put out, it is that reliance should not be placed exclusively on a single method of fire control. Again, the General Motors fire illustrates this point. Small fires were frequent—indeed almost expected occurrences in the plant. Previously, they had been controlled by using CO_2 extinguishers scattered throughout the plant. In fact, when the fire first broke out, those who were fighting it were not in the least concerned about their ability to control it with available equipment.

There is now general agreement that an automatic sprinkler system could have easily extinguished the fire without extensive damage. But only about 10 percent of the 1,500,000 square feet of Livonia's manufacturing area was protected by sprinkler systems—those installed in the shipping department and storage areas. It is ironic that additional sprinklers had been planned for areas containing combustible materials, but at the time of the fire contracts had not been let for the work.

Plants should be checked for the location and adequacy of fire hydrants and for distribution of fire-fighting appliances and reserve water supplies. Had firewalls been in the Livonia plant, the fire possibly could have been confined to the area in which it started; the administration building, which was protected with firewalls, suffered no damage from an otherwise totally destructive fire.

The physical construction of the plant may be important from the point of view of fire prevention and quite important from the point of view of fire control. Although 150 firemen with 31 pieces of mobile fire-fighting equipment were soon at the scene of the General Motors fire, none was able to enter the burning structure because of the dense smoke. An old-fashioned, manually operated, saw-tooth roof might have provided ventilation which would have permitted the smoke to escape.

Costs vs Benefits

In determining the value of a particular fire prevention and control plan, computing the costs of the various alternatives is easy. Cost estimates are ordinarily fairly simple to obtain.

Unfortunately, the same cannot be said for evaluating benefits. The benefits are the savings that will be realized by a reduction of fire occurrence or fire loss. The losses due to a fire are difficult to assess. Some, such as the loss of property and the loss of business while a plant is out of commission, are direct. Others, such as the loss of life and loss of customer good will, are less tangible.

The evaluation of benefits, however, is not completely impossible. Fire insurance companies have voluminous records to use in determining risks and that serve as the basis for establishing insurance rates. It is frequently possible to find the value that an insurance company places on specific preventive or control measures. Such a value is reflected in the change in insurance rates that accompanies a specific fire protection program. Even though a company may be partly self-insured, the rate reduction is a good indication of the monetary value of its program to reduce fire losses. This value may be compared to the cost of the program.

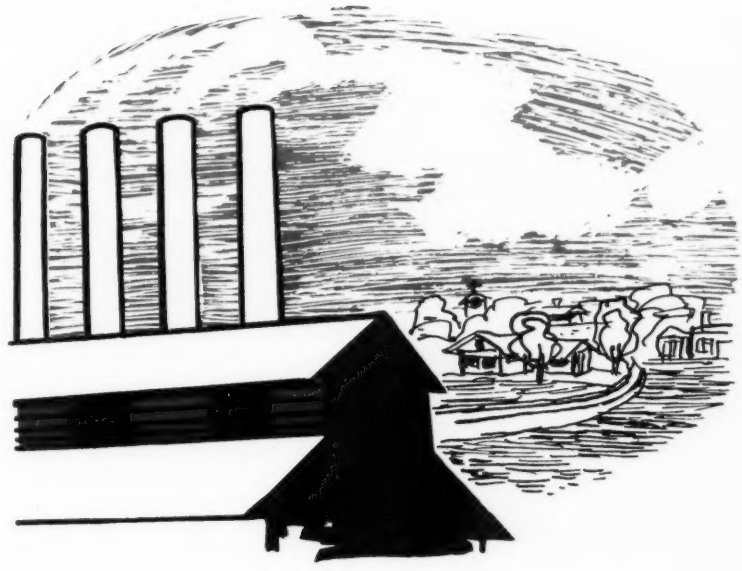
It is quite clear that any fire protection program must embody a systematic approach. No all-inclusive blueprint can be made; conditions vary from company to company. Alternatives providing for various degrees of protection should be developed and expressed in terms of cost. These costs should then be compared to the accompanying benefits of the reduced fire hazard. The most appropriate plan can be selected on the basis of such a comparison. Only in this way can business enterprises take advantage of the lesson to be learned from the tragedy at Livonia—the fire that need not have started and, once started, could have been controlled.

Fire Losses To Top a Billion

ESTIMATES by the National Board of Fire Underwriters place this year's fire losses over a billion dollars for the first time in the country's history. The one heartening factor is that the relationship between the losses and the value of property subject to damage is improving. This testifies to the rising effectiveness of the efforts to control fire.

Many industrial plants are no longer adequately protected however because new manufacturing processes have created increasing hazards. While fire prevention and fire fighting techniques have advanced at a pace comparable to this hazard-creating technology, actual application of these techniques is lagging far behind.

Air Pollution Abatement Recognized as Long Range Problem



ENCOURAGING PROGRESS toward air pollution abatement, together with increasing recognition of the impossibility of any quick solution of the problem, is indicated by reports coming from state capitals and municipalities throughout the country.

At a regional meeting of the Air Pollution Control Association this fall, Dr. R. E. Teague, Pennsylvania State Health Secretary, cited the gains made by Pittsburgh in its fight to curb atmospheric pollution. In eight years of smoke control, Pittsburgh has increased visibility conditions 75 percent, eliminated 65 percent of the dirt from the atmosphere, and practically wiped out smoggy conditions. "This atmospheric improvement," Dr. Teague said, "is the fruit of concerted action sparked by Pittsburgh's pioneer Bureau of Smoke Prevention and the sincere cooperation and continued support of public spirited industrialists."

Mobile Laboratory

To prevent reoccurrence of the 1948 disaster at Donora, when 22 persons were killed and nearly 6000 were made ill by atmospheric pollution, Pennsylvania has set up a mobile laboratory which is ready to aid air pollution control efforts in any part of the state. In explaining the state's role as coordinator in municipal abatement efforts, Dr. Teague said that since air pollution is primarily a localized condition, states must do more to aid smaller municipalities that cannot afford smoke control specialists.

Despite estimates by the Los Angeles County Air Pollution District indicating that industries in the county have spent $150 million on special abatement equipment, the county's smog problem remains very much a controversial issue. Far greater expenditures will be required to remedy the situation.

Bringing the Los Angeles smog issue back into the news was an open letter from the County Medical Association to Mayor Poulson, asserting that the smog seemed to be jeopardizing public health and urging a $5 million medical research program to determine its causes, effects, and possible remedies.

Mayor Poulson, who took office in July after making the smog problem one of his major campaign issues, stated his belief that the doctors were right. "We are in a desperate situation and drastic steps must be taken," he said. However, G. P. Larson, director of the district's pollution control authority, pointed out that just such a medical research program has been under way for two years as a joint project of the U. S. Public Health Service, the authority, and the University of Southern California Medical School.

The Los Angeles Authority, with power to invoke misdemeanor penalties for air contamination, has been centering its attention on eliminating as much atmospheric pollution from industrial sources as possible. Larson has stated repeatedly that, while progress is being made, the task cannot be accomplished immediately. "Everything in the atmosphere that contributes to smog," he said, "must be controlled—including oil refineries, motor vehicle exhausts, and backyard incinerators, along with scientific zoning of industry."

Long-Range Planning

Another example of increasing recognition of the long-range character of air pollution abatement is found in statements made by Dr. Leonard Greenburg, commissioner of the New York City Department of Air Pollution Control. "Working as we are on a limited budget, I think we are making real headway," he said. "Let us not be overly optimistic, however, and expect air pollution to be eliminated too quickly. Remember, New York has been developing sources of air pollution for more than 300 years, and no one can expect to eliminate a

problem of this size and scope in a short time. You can't lick a 300-year old problem without long-range planning and an intentional educational campaign."

Dr. Greenburg predicted that the record of his department for 1953 would double that of last year, and cited a long list of enforcement statistics to support his forecast. As soon as the department can be reasonably certain that all new fuel-burning equipment is being outfitted with anti-smoke devices, he said, "we will have taken a major step toward stopping the spread of air pollution in this city."

Oregon's State Air Pollution Authority recently advised the City of Portland that it would have to police its own smog problems. In a letter addressed to the City Council, C. M. Everts, Jr., secretary of the agency, stated that in addition to not having sufficient funds, the authority wishes to encourage and preserve "local autonomy in the field of air pollution control," and does not intend to encroach on activity which is a logical and proper function of the cities.

Seriousness of Chicago's air pollution problem has been pointed out by Dr. W. McCrone, senior chemist at Armour Research Foundation. Dr. McCrone took an active part in the formation of Midwestern Air Pollution Prevention Association which, a year ago, launched a research program aimed at finding out where Chicago's dust and smoke comes from and to promote research and education.

Noting marked progress in curbing air pollution in Richmond, Va., E. M. Andrews, the City's Chief of Air Pollution Control, declared in his annual report: "Few people realize how smokeless our community is now, as compared to a few years ago. Air pollution was at one time so prevalent that many people accepted it as a result of the industrial age. There were even those who actually looked on smoke emanating from the stacks of industry as a sign of prosperity ... In Richmond now, the sight of black smoke quickly excites unfavorable comment and a host of complaints."

Although citing various other sources of pollution, Andrews said industry is still the greatest source of contamination and requires the most effort for effective control. He expressed hope that all pollution sources soon may be controlled through better laws, study, and closer surveillance.

Court Trial

Popular misconceptions with respect to the air pollution problem were brought out during the September trial in Criminal Court, Louisville, Ky., which resulted in a jury finding a National Carbide Co. plant not guilty of air pollution charges. Experts called to testify included Dr. Louis McCabe, Chief of the Division of Fuels and Explosives of the U. S. Bureau of Mines, who called air pollution "the most complex problem of our whole civilized life, much more so than water pollution was 100 years ago."

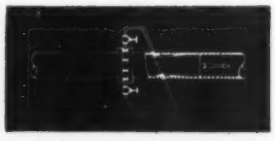
McCabe agreed emphatically with another authority's statement that "the nontechnical public is no longer able to detect a source of pollution as they are still trying to do in many communities." Referring to a provision set up by Kentucky law, he also said it was impractical to try to tell the density of dust being discharged by "any sort of visual test." Replying to a defense counsel question, McCabe said he fully agreed that " it is a common expectation to have one segment of the public fasten on one particular source of effluent as the source of all pollution in an area." National Carbide contended it was being made the whipping boy for all its neighbor plants.

Tax Concessions

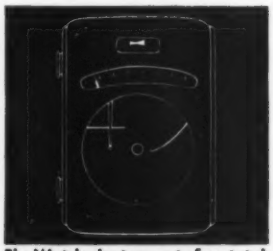
Of far-reaching potential significance is a Wisconsin legislative enactment giving industries special state tax concessions for money spent on facilities for abatement of air and water pollution.

The Wisconsin act exempts such equipment from local property taxes for five years and allows industries, for state income tax purposes, to amortize cost of the equipment over a five-year period instead of over 20 years. The tax concessions will be allowed for equipment installed by order of state or local enforcement agencies.

BUILDERS FLOW METERS



Model NZIF Venturi Insert Nozzle.



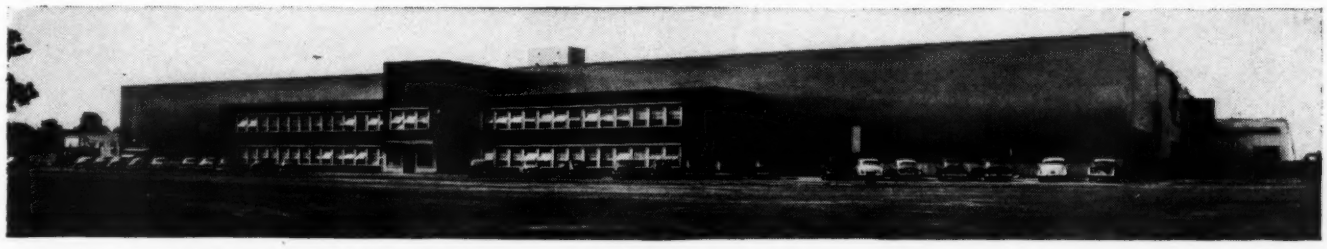
Flo-Watch Instrument for totalizing, indicating, and/or recording flow.

Builders Chronoflo Telemeter for transmitting flow information over any distance.

Builders-Providence, Inc., the Instrument Division of B-I-F Industries, has been engaged in uninterrupted research and development in instrumentation since the invention of the Venturi Tube by Clemens Herschel in 1887. Builders now furnishes municipalities, power plants, and industries with improved Venturi Meters as well as a wide variety of instruments for metering and controlling flow, liquid level, temperature, pressure, weight. For Bulletins, address Builders-Providence, Inc., 512 Harris Avenue, Providence 1, R. I.

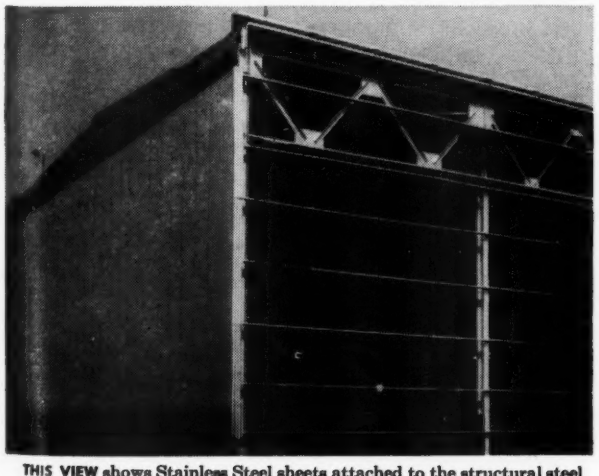
BIF INDUSTRIES **BUILDERS** (DIVISION OF B-I-F INDUSTRIES) BUILDERS

SHEETS OF STAINLESS STEEL enclose the 34 to 36 foot walls of the new plant of United States Steel Homes, Inc. near Harrisburg, Pa. Stainless sheets were fabricated and erected by American Bridge Division of United States Steel Corporation, and the general contractor was Ritter Brothers, Harrisburg.



Walls of Stainless Steel will keep maintenance costs low in this new plant of United States Steel Homes, Inc.

HERE WORKMEN are bolting the 30" corrugated Stainless Steel sheets to the structural steel frame. Erection is fast and simple; it requires a minimum crew and can be carried out in any type of weather.



THIS VIEW shows Stainless Steel sheets attached to the structural steel framework of the plant. All flashing and trim is Stainless Steel, too.

HERE is one of the largest industrial structures to emerge from the growing trend toward use of Stainless Steel for exterior walls. It's the new plant of United States Steel Homes, Inc.—formerly Gunnison Homes, Inc.—located near Harrisburg, Pa.

The plant is an "L"-shaped structure with approximately 310,000 square feet of floor space. The entire exterior is covered with sheets of 26-gage corrugated Stainless Steel, used in 30" widths. Approximately 55 tons of Stainless Steel were used.

Reduction of maintenance costs was the primary reason for selection of Stainless Steel sheets. The walls will not require painting and a long, trouble-free life is anticipated. And, in addition, Stainless Steel gives the plant an attractive over-all appearance.

Stainless Steel sheets and panels offer so many advantages, both in construction and through the life of the building, that their cost-per-year is lower than almost any other material. They are considered outstanding developments in architectural circles today.

Panels are available uninsulated or with filler-type insulation between the exterior Stainless sheet and the interior sheet of carbon steel. This makes them suitable for the widest range of building types—plants, warehouses, power plants, office buildings and many others.

If you would like more information on Stainless Steel sheet and panel construction, mail the coupon below.

United States Steel Corporation
525 William Penn Place, Room 2819-D
Pittsburgh 30, Pa.

☐ Please send me your new booklet on U·S·S 17 Stainless Steel for industrial buildings.

☐ Please arrange to have fabricators of Stainless Steel wall panels send me literature on their particular type of construction.

Name ..... Title .....

Address .....

City ..... State .....

United States Steel produces only the Stainless Steel sheet and strip from which panels of this type are made; the panels themselves are fabricated by a number of our customers.

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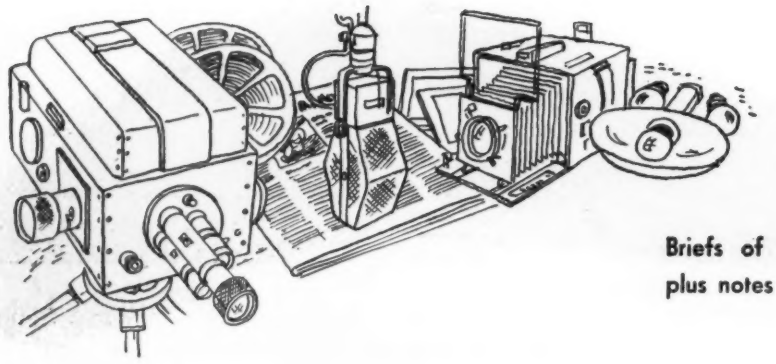
SHEETS · STRIP · PLATES · BARS · BILLETS · PIPE · TUBES · WIRE · SPECIAL SECTIONS

3-2084

UNITED STATES STEEL



NEWS

Briefs of current interest to the consulting profession plus notes on new equipment in the field of engineering

"Air-Borne" Concrete Used in Induced Caving Project

A "push-button" system of blowing concrete by compressed air through pipe from underground mixing stations into construction forms has been installed by the International Nickel Co. of Canada, Ltd, at its Creighton Mine. Extensive concreting is necessary to stabilize areas of the mine worked and abandoned 40 or more years ago, and to utilize old openings in which the timber supports have rotted and collapsed.

Concrete mixing stations are located on the 6th and 20th levels. The mixers, which can produce a 16-cu ft batch every three minutes, pour it into the placer into which compressed air is then introduced from the mine's main air line. The concrete is blown through a line of steel pipe which carries it through the mine and finally drops it right into the forms at the construction site.

At 90-degree turns in the line T-bends are used. On long curves, sections of 8-in. pipe are inserted, with Ni-Hard liners; standard steel elbows last as little as two hours under the impact of the concrete, but the nickel alloy liners were unchanged after six months of operation.

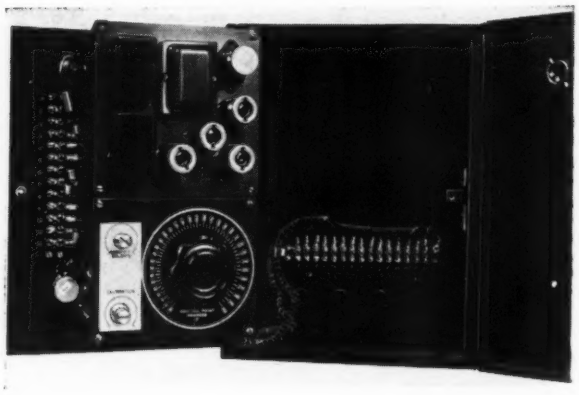
Part of the concrete is being used to line an underground airway which will funnel fresh air to workings almost a mile below surface. ▲▲

Power Project Expected to Increase Capacity Fifty Percent

When both generator units of the River Rouge Power Plant project are in operation and the new St. Clair plant is completed, Detroit Edison's total generating capacity will be more than three million kw, four million hp. This is a 50 percent increase over the present capacity.

Two of the world's largest steam turbine-generators—260,000 kw each—will be housed at the River Rouge plant. On the 125-acre plant site will be dockage for lake coal-carriers and storage facilities for over one million tons of coal.

The powerhouse superstruction will be of steel panel design. About 3000 twelve-inch steel casings, driven 90 ft into the ground and filled with concrete, are required to support the foundations. ▲▲



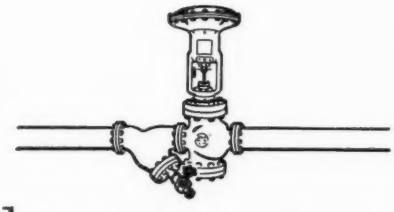
Precision Controller Is Suitable for Varied Uses

The flexibility provided by the different modes of control available with a new electronic temperature controller is expected to make the unit applicable to a variety of industrial uses: heating applications; the metals industry; and for research.

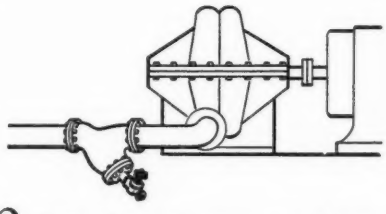
Introduced by the Industrial Division of Minneapolis-Honeywell Regulator Company for industrial applications requiring precise and consistent temperature control but not requiring the functions of

Which of over 150 Leslie strainers is the one for YOUR job?

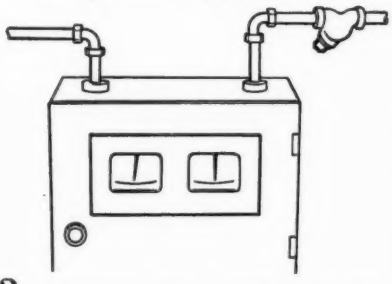
THREE "MUSTS" FOR GOOD PIPING PRACTICE . . .



1. **For protection of control valves.**



2. **Protection of pumps, turbines and process equipment.**



3. **For superfine cleaning of air, steam and liquid flows, Leslie "Poromet" filters trap particles down to .001".**

WHICH WILL GIVE COMPLETE PROTECTION AT LOWEST COST?

Just considering strainer body material and screen specifications alone, there are over 150 *standard* combinations of "Y" type Leslie strainers. Each is engineered to do specific jobs under specific conditions . . . there's a "Leslie" for any industrial or marine pipeline strainer application.*

Then, with the myriad of pipe sizes and end connections, it's apparent that picking the right strainer to protect valuable equipment exposed to flow is *not* a "pin-the-tail-on-the-donkey" task.

***There are standard units for pressures to 2500 psi; temperatures to 1050° F; semi-steel, cast bronze, cast steel and cast alloy steel; screwed, flanged, welding or ring-type ends; sizes from ⅛" to 10".**

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THE FIRST NAME IN PRESSURE, TEMPERATURE AND LEVEL CONTROLS
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Controller Has Varied Uses

—*Starts on page 52*

indicating or recording, the 077 line of controllers includes single-point and cascade control models in three ranges: -20 to 220 F, -20 to 300 F, and -100 to 600 F. Sensitivity for the first two ranges is ± 0.1 F, and for the third range ±0.9 F.

In the single-point model, the control method may be on-off two-position, floating, or proportioning: the motor or final control element determines the type of control used. Colored lights indicate when temperature is at set point, above, or below it. ▲▲

Portable Drawing Board Will Fit in Briefcase

Small enough to be slipped into a briefcase, a portable drawing board molded of clear polystyrene plastic should prove useful to engineers, draftsmen, contractors, and architects.

Four recessed corner clamps are used to attach 8½x11 in. paper without the use of thumbtacks or scotch tape. Two retractable metal straight edges, one vertical, one horizontal, make possible precision work without the use of a T-square. On the underside of the eight ounce board are tension clamps for secure storage of triangles. The manufacturer is The Graphostat Co., 110 Eaton Place, East Orange, New Jersey. ▲▲

Part-Time Graduate Study Inaugurated at Cincinnati

Joint efforts of the engineering societies, a local industry committee, and the administration of the University of Cincinnati have resulted in a series of part-time graduate engineering courses for practicing engineers and scientists.

The three groups responsible for the plan have participated during the past year in a nation-wide program of the Engineers' Council for Professional Development, which is aimed at stimulating the continued personal growth of the young engineer.

In line with the increasing demand for engineers, New York University reports that 1953 engineering graduates started work at salaries five percent over the 1952 starting wage, averaging $345 a month. Almost 71 percent of this year's New York University graduates took jobs in private industry. ▲▲

Second Turbo-Generator Is in Operation at Bokaro, India

Boilers 3 and 4 and the second turbo-generator have been placed in operation at the Bokaro Thermal Power Plant now being built in India as part of the Damodar Valley development program. The first turbo-generator with boilers 1 and 2 began operation when the huge plant was dedicated by Prime Minister Nehru in February. When completed, this station will operate on four 50,000-kw hydrogen cooled turbo-generators and eight 300,000-lb-per-hr boilers.

The entire project — from designs, engineering, purchasing, and construction to initial operation — is being handled by The Kuljian Corporation. This is the first high-pressure steam generating plant in the Far East, and is part of an immense power program which India has undertaken with the help of funds secured through the World Bank, and with engineering and construction "know-how" supplied by the United States.

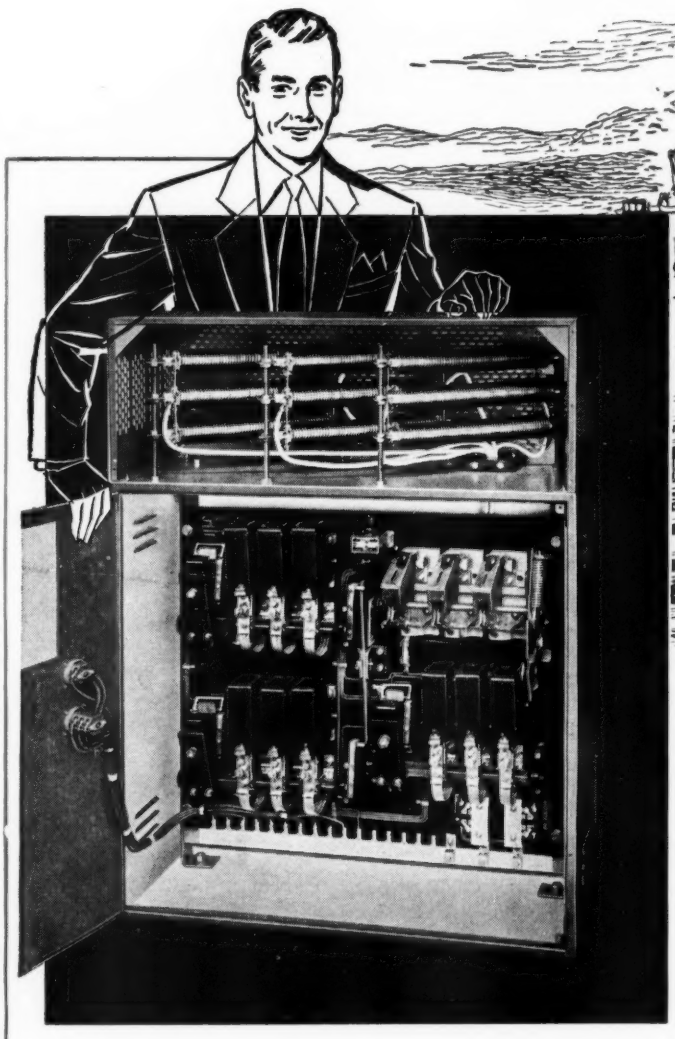
See "Ventilating India's Bokaro Steam Station," CONSULTING ENGINEER, March, page 64. ▲▲

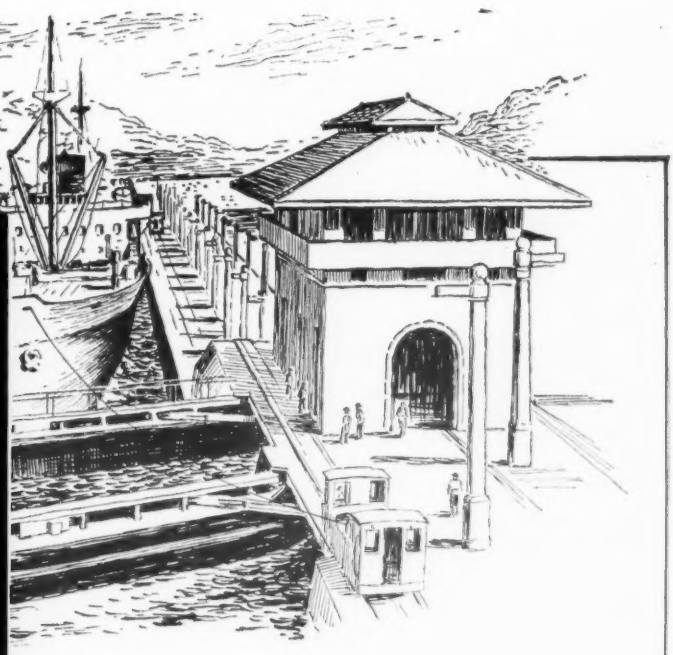
Temperature Remains Constant With Use of Ventilating System

By rotating metallic wool in counterflowing air streams the Therm-O-Wheel is said to permit almost complete transfer of temperatures between exhaust and fresh make-up air.

Exhaust air is blown through the upper half of the Therm-O-Wheel and ducted out of the building. The wheel revolves slowly so that the heat picked

IT'S FEDERAL NOARK® MOTOR CONTROLS FOR THE PANAMA CANAL





ABOVE: View of the upper pair of the Miraflores locks and one of the control towers from which the new Federal Noark motor controls are operated.

AT LEFT: Interior view of one of the eight types of motor controls built for the canal project.

THE PANAMA CANAL is now undergoing an extensive modernization program. One phase requires new electric motor controls for the locks...and Federal Noark devices are being installed. These controls will assure the safe, efficient motor starting required for rapid and continuous canal service.

Special processes in the manufacture of these 398 motor controls were necessitated by the specifications. Wire insulation, for instance, and other parts likely to deteriorate under tropical conditions had to be protected against "attack by insects, especially cockroaches and termites," and made fungus-proof with suitable shellac. To accomplish this, Federal engineers treated each part separately before assembly.

Whether your control problems are simple or as complex as those for the Panama Canal, call in Federal Noark for the right solution.

Write Federal Electric Products Company, 50 Paris Street, Newark 5, N. J.

Plants at Newark, N. J.; Long Island City, N. Y.; Hartford, Conn.; Cleveland, Ohio; Gary, Ind.; St. Louis, Mo.; Dallas County, Texas; Los Angeles, Calif.; San Francisco, Calif.; Santa Clara, Calif. Affiliated plant, Toronto, Canada.

Federal Noark products: Stab-lok Circuit Breakers, Motor Controls, Safety Switches, Service Equipment, Industrial Circuit Breakers, Panelboards, Switchboards, Control Centers, Bus Duct — **Pacific Electric Manufacturing Corporation products:** High voltage circuit breakers and power switches ★ Sales offices in principal cities.

FEDERAL NOARK®

Temperature Remains Constant

—*Starts on page 54*

up from the exhaust air by the metal wool in the wheel is in turn picked up by the incoming air stream. In this way, fresh air enters the building at almost the same temperature as the exhausted air.

It is said to retain up to 96 percent of heat or cold generally lost through ventilation and to operate efficiently in any degree of temperature-difference between exhausted and incoming air.

Designed to keep maintenance at a minimum, the wheel is supported by tapered roller bearings, grease packed and sealed. Since it revolves slowly, wear is negligible, and the assembly is arranged for easy maintenance according to the manufacturer, Therm-O-Wheel, Inc., 1042 Twenty-Second St., Far Rockaway, N. Y. ▲▲

Permanent Magnetic Pulley Used to Handle Bauxite Ore

One of the world's largest and most powerful permanent Alnico magnetic pulleys—42 in. in diameter with a 36 in. width belt—is being used at the Mobile, Alabama plant of the Aluminum Co. of America.

Made by the Homer Manufacturing Co., the pulley handles up to 600 tons per hour of bauxite ore. It is installed in a 200-ft long slope conveyor, operating at 27 rpm, giving a belt speed of 300 fpm. At times the depth of the material handled runs as much as eight inches. ▲▲

Japanese Companies to Install American-Made Power Plants

Three complete Westinghouse 75,000-kw thermal electric power plants, costing approximately $29½ million, have been ordered by the Kyushu Electric Power Co., Inc., and the Kansai Electric Power Co., Inc., of Japan.

First of their size ever exported from this country, the high efficiency units are part of a vast program now under way in Japan to expand the electric power facilities of that country.

Two of the three units will be installed in central Japan at Tanagawa Station near Osaka by the Kansai Co. They will be combined into a complete 150,000-kw steam power plant with two generating units of 75,000 kw each, designed to operate at high temperatures and pressures. This company serves the cities of Osaka, Kobe, and Kyoto, whose industries include metals, machinery, chemicals, ceramics, textiles, and shipbuilding.

The Kyushu plant will be identical in design to the Kansai unit, but will consist of a single unit of 75,000 kw. It will be located at Karita, on the island of Kyushu in southern Japan. Basic metals and chemicals are produced in the area, which also mines half of Japan's coal.

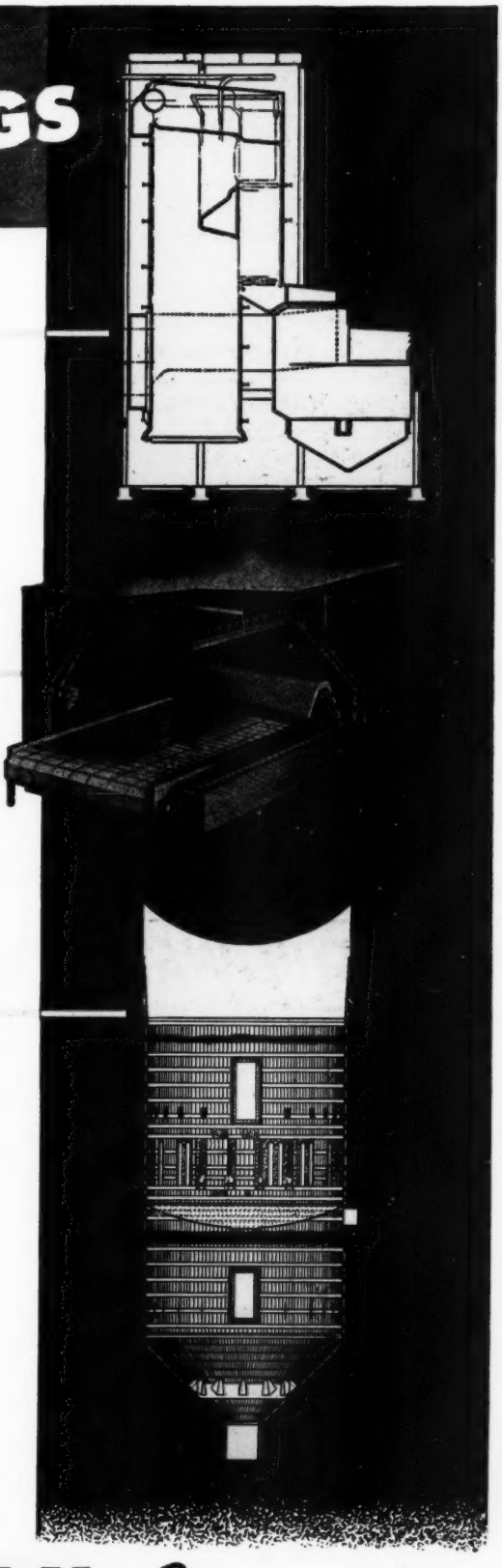
Buildings on both orders, though designed by Westinghouse in this country, will be constructed by the Japanese. Installation of all equipment also will be done by the Japanese but under the supervision of Westinghouse engineers. It is expected the new plants, equipped to burn either oil or low quality pulverized coal, will be ready for operation in 1955. ▲▲

Flexible Metal Tubing Is Used in Prestressed Construction

Architects and engineers have long recognized the advantages inherent in prestressed design. By application of this principle, a structure can be built with only half the concrete and scarcely a third of the steel required for corresponding structure in reinforced concrete.

For prestressed construction, the Stressteel Corp., is using interlocking flexible metal tubing. In the actual operation, the tubing is fully elongated and cut to a length equal to the bar to allow sufficient tubing to project beyond the forms in order to protect the bar threads and prevent concrete from entering the space between the bar and the tube. The bar is then inserted into the tubing, which is positioned in the formwork. Concrete is poured in. After the forms are removed, the tubing is stripped

RIGHT IN THE HEAT OF THINGS



in Power Plants

. . . you'll find economy-minded B-L boiler enclosures in power plants all over the country. Size poses no problem: B-L engineers them all from small HRT settings to huge 10-story jobs like the one illustrated.

in Chemical Plants

. . . Bigelow dryer furnaces deliver a tremendous volume of hot gases—as much as 93,000,000 BTU's—at predetermined temperatures to rotary dryers. Furnaces process coal, sugar, salts, grain—any product from which moisture must be removed.

in Oil Refineries

. . . B-L offers a complete, one-source service of engineering, materials, and erection help for castable regenerators and pressure vessels of all kinds. Construction can be either castable, tile or a combination of the two.

yes, and in the metal, glass, cement and sugar industries (others, too!) B-L enclosures are right *in the heat of things.* Write today for complete information.

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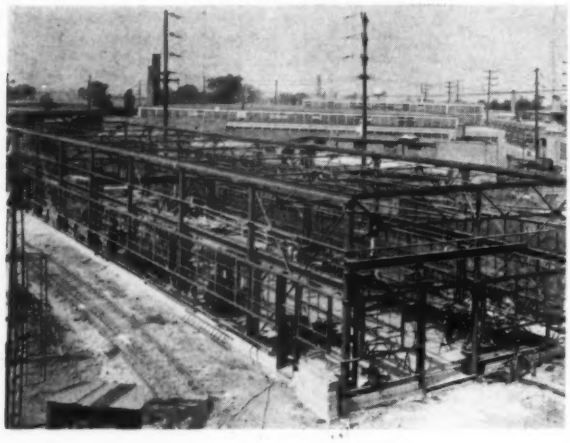
Tubing Used in Construction

—*Starts on page 56*

back to the face of the concrete. The prestressing operation follows.

The tubing used is a product of the Atlantic Metal Hose Co., Inc., 123 West 64th St., N. Y. ▲▲



Structural Pipe Used In Building Erection

Utilizing its own pipe fabrication facilities and its own stocks of structural pipe, the L. B. Foster Co. erected approximately 6000 sq ft of manufacturing space at its Chicago plant in a month's time.

The increased manufacturing facilities were necessary for the Foster Portable Pier, a patented development which enables a lake-home owner to install 30 ft of pier in less than two hours without entering the water. A conventionally planned building using structural shapes had already been designed, but it was found that fabricated steel would not be available in time to meet shipping dates for the new pier.

Standard 1½ to 9-in. standard steel pipe was used instead of structural shapes for all columns, trusses, joists and bracing. No special fittings or attachments were necessary in the erection of the pipe frame, and the building was designed to allow the use of field erection bolts so that it may, if desired, be dis-assembled and re-erected in another location.

Structural steel was used for the girt framing, eave struts and crane beams. A five-ton overhead crane has been installed. The building is 160 ft long and 38 ft wide with an 11-ft clearance provided for the crane. Corrugated siding was used for wall construction; the roof is prefabricated steel roof decking; and a six-in. concrete slab forms the floor.

The frame was erected in three weeks and another week was required to erect the roof and wall siding. ▲▲

NEW TYPE WATER FILTER . . . for industrial plant water, municipal water supply and swimming pools

The SPARKLER Model SCJ *Diatomite* self cleaning filter

—combines the uniform consistant quality of diatomite filtering with a quick cleaning system of jet spray wash off of plates and backwash.

The filtering element is composed of orlon cloth covered screen discs that readily take an even pre-coat of diatomite circulated from a slurry tank.

The filter cake can be quickly and completely washed off with a built-in jet spray and the filter cleaned by backwash with a minimum of backwash water and plates recoated ready to resume service within a total cleaning time of 10 to 15 minutes.

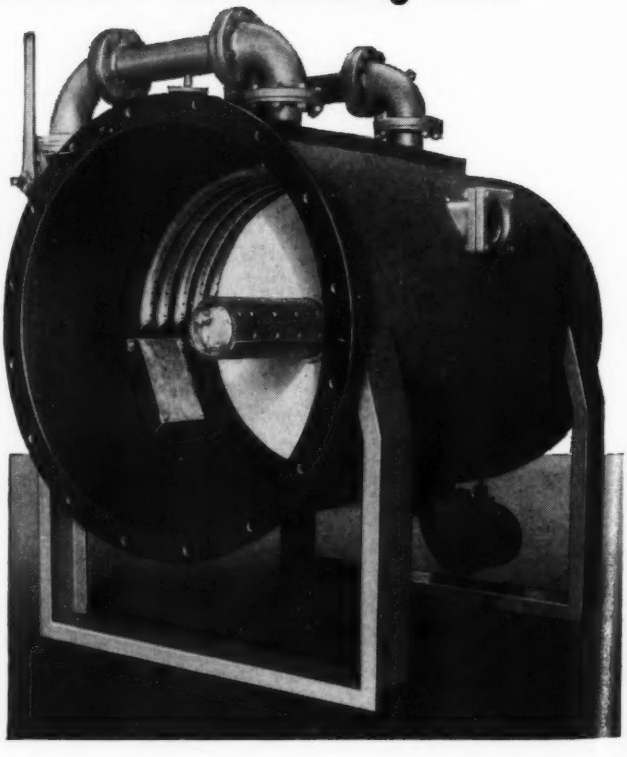
For the first time, in this new development, Sparkler Engineers have successfully combined the desirable features of diatomite filtering and fast self cleaning, without bridging or loss of filtering surface and with the use of very little filtered water at a low flow rate. The distinctive advantages of this type of filter are:

1. Removal of 80% to 100% of bacteria depending on the type of bacteria and the grade of diatomite used in addition to all suspended matter either colloidal or solid. Thus the required chlorination is reduced materially.
2. First cost of a SCJ filter installation is about half that of a sand filter of equal flow capacity.
3. Floor space required for a Sparkler Model SCJ filter is much less than usually anticipated when compared with some other types of filters. The large size SCJ filter with a capacity of 96,000 G.P.H. requires a floor space of only 97" x 77" with overall height of 84".
4. Operation is simple and can easily be handled by any plant mechanic.

Standard single SCJ filter units available in capacities up to 96,000 G.P.H. Multiple units can be used for larger requirements. Also, larger single units can be custom built when desired.

Personal supervision of each installation is made by a Sparkler engineer.

WRITE MR. DAN D. BALDWIN FOR PLANS AND PRICES ON YOUR REQUIREMENTS

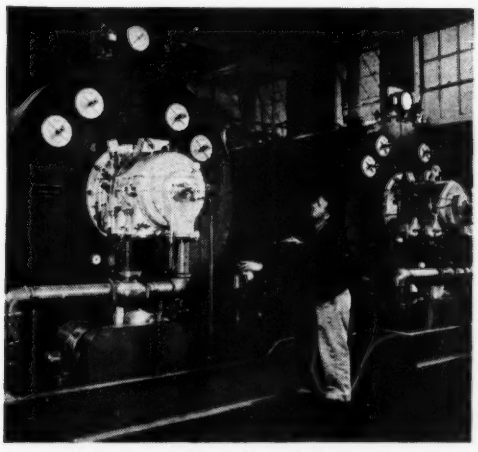


SPARKLER MANUFACTURING CO., Mundelein, Ill.

MAKERS OF FINE FILTERING EQUIPMENT FOR INDUSTRIAL USE FOR OVER A QUARTER OF A CENTURY.

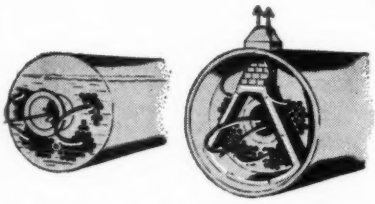
9 REASONS WHY

STEAM COSTS GO DOWN

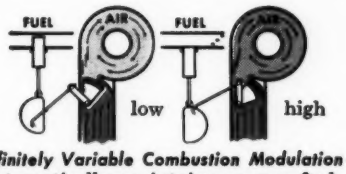


Completely Automatic Operation—Full complement of finest up-to-date operating and safety controls provides maximum operating dependability and protection with least possible attention from operator

.....where *Powermasters* go in ...

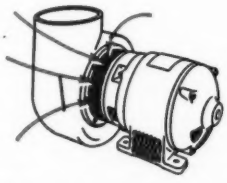


3-Pass Boiler with successive parallel paths and single gas flow reversal at each end assures most efficient flue gas velocity and heat transfer, provides maximum maintenance convenience, and requires no complex front end baffling.

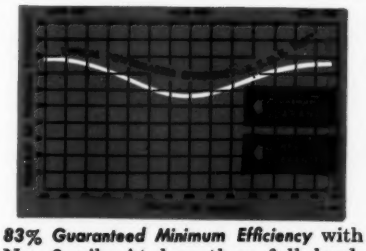


Infinitely Variable Combustion Modulation automatically maintains proper fuel-air ratio for most efficient firing at all loads. Instant response to load swings between 20% to 100% of firing rate saves fuel and assures constant steam pressure and temperature.

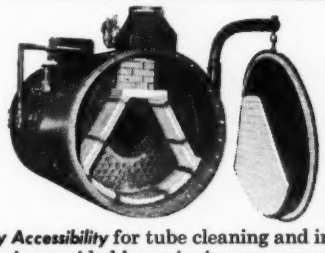
Staggered Tubes—Freedom from ineffectual boiler water eddies assures quicker heating, faster steaming, and high quality dry steam. Scrubbing action of rising water prevents corrosive gas deposits on tube surfaces.



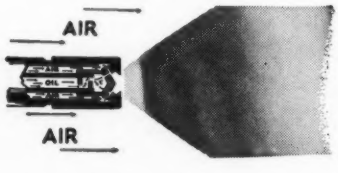
Forced Draft provides most accurate control of combustion air supply; permits use of smaller, low-cost stack, fan and motor; requires less fan maintenance because no hot products of combustion pass through the fan.

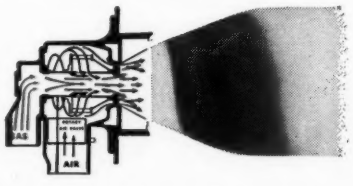


83% Guaranteed Minimum Efficiency with No. 6 oil. At less than full load, *Powermaster efficiency* actually increases! ASME field tests prove *Powermaster's* superior performance.



Easy Accessibility for tube cleaning and inspection is provided by swinging rear cover, and divided front cover that is readily removable without disturbing burner or accessories. Convenient handholes facilitate waterside inspection.





Variflow Burners keep fuel costs low and boiler efficiency high at all loads. Air-atomizing oil burner (left) and pre-mix gas burner (right)—designed by O&S expressly for *Powermaster*—provide complete, clean combustion over full firing range. Simple, sturdy construction with no moving parts, absence of vibration, and ease of cleaning minimize maintenance. Combination burner allows quick change from one fuel to another.

Compare *Powermaster*, feature by feature, with any other package boiler and you'll readily understand why it is so widely used in industrial plants, dairies, hospitals, laundries, schools, public buildings, housing projects, institutions, and many other applications ... and adding new users at a rapid rate.

Send for this NEW BULLETIN

Describes and illustrates all cost-saving features of the modern, completely assembled, and factory fire-tested *Powermaster*. Ask for Bulletin 1219 on your company letterhead, stating your steam requirements and operating conditions.

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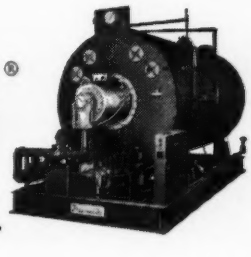
PACKAGED AUTOMATIC BOILERS

In sizes to 500 HP; pressures to 250 psi.



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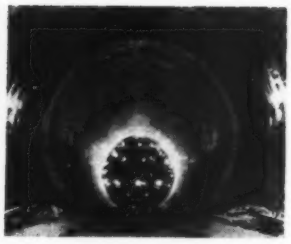


Niagara

—Starts on page 20

to grayish-black shale. It is soft and thinly-bedded, and will not support its own weight.

The Thorold is a massive to slightly banded, light gray, fine-grained, quartzose sandstone. It is hard, intact and dense, with a slight tendency to part along directions of cross-bedding.

The upper 15 feet of the Grimsby is a massive, slightly stratified, red ferruginous sandstone. Toward the bottom it becomes progressively more stratified with a growing incidence of shale parting the submembers. The reaction of some of these shaly members to stress relief during excavation caused minor difficulties in benching cycles until excavating methods were altered to meet the condition.

Rock Clearance

Broken rock is cleared by either diesel or electric shovels. Although rated at 2½ cubic yards, the shortened booms and dipper sticks used for working in close quarters enable these shovels to handle a 3½ yard bucket. A bulldozer and tractor-mounted overhead loader are used for cleanup. The rock is loaded by the shovel into 14 yard diesel dump trucks which dump it through a grizzly to a skip-loading pocket located directly below the shaft crosscut. Average clearing time is about 4 hours for a 16- to 18-ft round.

Two main areas have been established for the disposal of material excavated from the tunnels. A disposal area on nearby Mountain Road is being used to hold all the material excavated from the Queenston end of the work. The area for the Chippawa end is established close to Shaft No. 1.

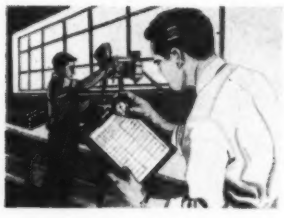
Altogether, five large tracts of land have been set aside for the Niagara project. These areas, totalling approximately 640 acres, provide space for all excavated material. On completion of the project, these disposal areas will be graded and landscaped. In order to reach these points, 25 miles of heavy-duty construction roads have been built.

ACKNOWLEDGMENTS

H. R. Rice, Editor, *Canadian Mining Journal.*

Charles MacIntosh, Public Relations Officer, The Hydro-Electric Power Commission of Ontario.

Information Division, The Hydro-Electric Power Commission of Ontario.



Incentives

—Starts on page 24

alities could be removed. One specific way of making the process impersonal is by using pre-determined work standards.

Pre-Determined Time Standards

Pre-determined time standards are a technique by which a standard is set on the method rather than on the operator. By establishing the method and the allowed time prior to accomplishment of task, the human factor is circumvented. The technique also has the advantage of allowing standards to be set more quickly.

The fact that pre-determined time standards are gaining wide acceptance throughout industry shows that some progress is being made in recognizing the importance of the human factor.

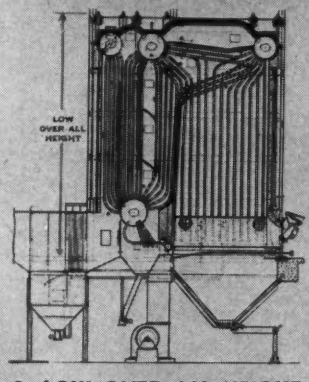
It has been the opinion of the author that the benefits to management from an incentive system do not result so much from a quickened work pace, but from keeping the worker at his task, eliminating time away from the job, and getting the potential from a machine or work station.

If a workman operates his machine correctly and does not shut it down unnecessarily, he will have produced a satisfactory quantity for the work period without undue exhaustion or over-strenuous efforts. The same is true of an assembly station although increased skill and effort can have more effect on results. If an assemblyman performs the work required in the prescribed manner, avoids delays, and stays with the job all day, there is usually no problem of inadequate production.

Conclusions

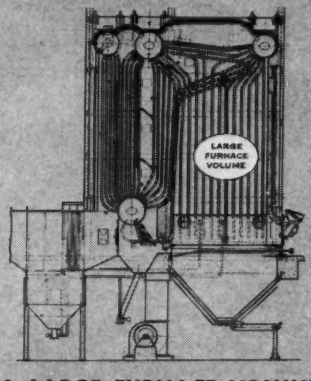
Pre-determined time standards are not a panacea for incentives. This technique, like its other predecessors, is only a tool. It can be used correctly or incorrectly. Too many managements have abused incentive systems and will continue to use them unfairly for any dream of utopia to materialize. Any tool, and the incentive system is one, is only as good as the use it is put to, and only as effective as its upkeep. It will not run itself, it requires care; but most important, because it deals with human beings and concerns their very livelihood, it must be used fairly if it is to overcome the handicap of its present unpopularity.

Add the Advantages...



3. LOW OVER-ALL HEIGHT

+



4. LARGE FURNACE VOLUME

=

Formerly, to get desirable large furnace volume in a watertube boiler you had to accept an awkwardly high over-all height. Now, BROS offers this large furnace volume within conservatively low over-all height, largely through compact vertical design of elements. Thus your boiler room space is utilized most effectively. A BROS boiler gives you maximum furnace volume and maximum flame travel per foot of over-all height!

You'll Choose BROS

Shown here is a BROS 4-drum Watertube Boiler installation at the municipal plant of a progressive midwestern city. Plant produces heat and generates electric power.

Before you specify your next steam generating unit, talk to a man from BROS. He can tell you concisely what a BROS-designed watertube boiler offers you. Two of the points are illustrated above. Since 1888 BROS engineers have specialized in these features which make boilers deliver the most steam for the least money in a specified application. Many of these BROS advantages are exclusive. Find out how they can serve you!

Second in a series of ads describing BROS advantages, point by point. ADD THE ADVANTAGES... YOU'LL CHOOSE BROS!

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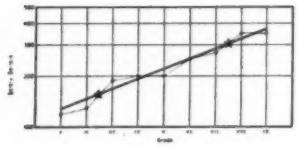

Semiaveraging

—Starts on page 30

produced. Because each observation is time-consuming, and because months would pass before all yarn sizes would come up for a run, the time-study engineer confines his observations to a scattering (but an adequate sample) of yarn sizes being run currently. He plots the data from observations of the samples selected, calculates a line of best fit, and determines machine speeds for all intermediate yarn sizes by interpolation from this line. The data are plotted as shown in Figure 2. Since random observations were taken, spacings of yarn sizes along the horizontal axis do not occur at regular intervals. This requires a slightly different (but just as simple) treatment in the calculation than did the previous example. This difference involves finding the horizontal midpoint (which in Figure 1 was plain by inspection). In this case, it is found by averaging the horizontal or "X" values (sizes of yarn) for all the plotted points:

X		Y	
1.0		5	
1.5		7	
2.6		8	
3.4		10	
5.0	$13.5 \div 5 = 5.7$	13	$43 \div 5 = 8.6$
7.2		16	
9.0		18	
11.9	$28.1 \div 3 = 9.4$	24	$58 \div 3 = 19.3$
$41.6 \div 8 = 5.2$			

Average values of "X" and "Y" for the two sections of Figure 2, which determine the two points for the line of best fit, are plotted as before:

$X = 2.7; \quad Y = 8.6$
$X = 9.4; \quad Y = 19.3$

A job evaluation study provides a still different example. Several salary grades are established, the average salary paid for jobs in each grade is calculated and it is required to pass a line of best fit through these points to obtain an orderly progression of salaries from grade to grade.

When these salary points were first plotted on linear coordinate graph paper, the result was not a straight line, but a line curving more and more steeply upward from left to right. The reason for this was that the company had historically recognized more or less constant percentage increments rather than constant dollar increments between jobs of greater and greater importance. They also granted salary increases on a more or less constant percentage basis. The line of best fit is more truly represented by an exponential curve on linear coordinates than a straight line. An exponential curve becomes a straight line on semilogarithmic paper. Since a straight line is easier to handle in calculating lines of best fit, semilogarithmic graph paper was selected.

The line of best fit is calculated exactly as in the first sample with the exception that amounts on the vertical scale ("Y") must be the logarithm of the number instead of the number itself. This might pose a problem when logarithmic tables are not readily available or when logarithms are not used enough to keep in practice (a slide rule will not suffice because it cannot be read accurately enough). Furthermore, logarithms are cumbersome to handle in multiplication and division.

Distances for Logarithms

Fortunately, there is a very useful and simple dodge to avoid using logarithms. Since the vertical distances above the base line are proportional to the logarithms of the numbers on the "Y" scale, distances can be substituted. These distances can be measured in fractions of an inch.

Assume that in this job evaluation study there are nine salary grades and that the average salary in each grade has been plotted on semilogarithmic graph paper as in Figure 3. Measuring values of "Y" in 32nds of an inch, values of "X" and "Y" for the plotted points are set up in tabular form thus:

X		Y (32nds of inch)	
I		8	
II		12	
III		30	
IV		32	
V	III	32	$114 \div 5 = 22.8$
V		32	
VI		42	
VII		46	
VIII		58	
IX	VII	58	$236 \div 5 = 47.2$

Division of the graph into two sections puts Grade V on the dividing line. Therefore this grade and its "Y" point "32" are used in calculating the midpoints of both sections as indicated. The line of best fit is then drawn through these points:

X = Grade III; Y = 22.8/32nds of an inch
X = Grade VII; Y = 47.2/32nds of an inch

In these three examples, which are typical of a large variety of graphs, differences between lines of best fit determined by this simplified method and those calculated by the classical "sum of least squares" procedure are scarcely visible to the naked eye. In most cases the differences would be less than the range of possible error in the original data. And the semiaverages method takes only about one third the time and effort.

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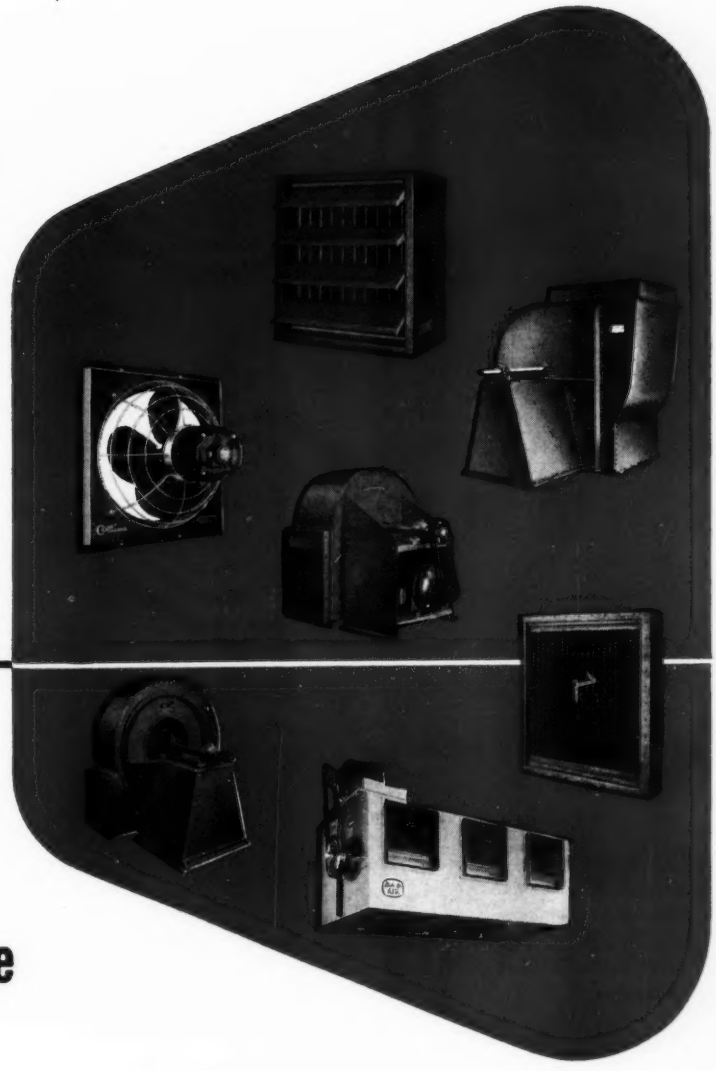

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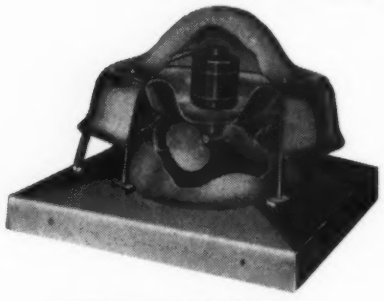

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MEN IN ENGINEERING

★ The appointment of L. C. Messick as director of the newly formed National Lighting Bureau is announced by the National Electrical Manufacturers Association. J. H. Jewell, vice president of Westinghouse Electric Corp., was elected president of the NEMA. He succeeds Lyle G. Hall, president of Stackpole Carbon Company.

★ Harry A. Winne, long recognized as one of the nation's foremost authorities on engineering, has retired as vice president of the General Electric Company after 43 years of service. On special assignments for G-E president Ralph J. Cordiner since May, he will continue his headquarters at the Schenectady offices until the end of the year to complete those assignments.

★ Holtzer-Cabot Telephone Equipment Division of National Pneumatic Company, Inc., and Holtzer-Cabot Divisions, announce the appointment of C. H. Achenbach as consulting engineer in the development of telephone power equipment.

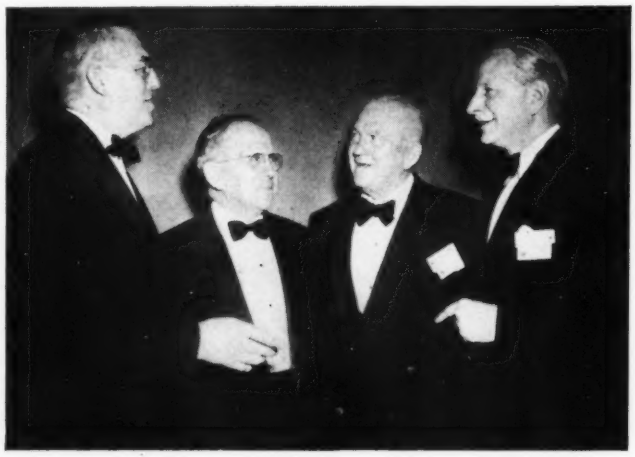
★ Col. Willard F. Rockwell, chairman of the board of Rockwell Manufacturing Co., is one of four Pittsburgh industrialists re-elected to the National Industrial Conference Board for a term of one year. He is also named chairman of the board of the new Rockwell Spring and Axle Co., which was formed by a merger of Standard Steel Spring Co. with Timken-Detroit Axle Co.

★ Appointed to the staff of the Frederick S. Bacon Laboratories, Chemical Research and Development Consultants, is Andrew A. Root. Prior to this new association, he was an assistant professor at the Massachusetts Institute of Technology and a consultant to the United States Ordnance Department.

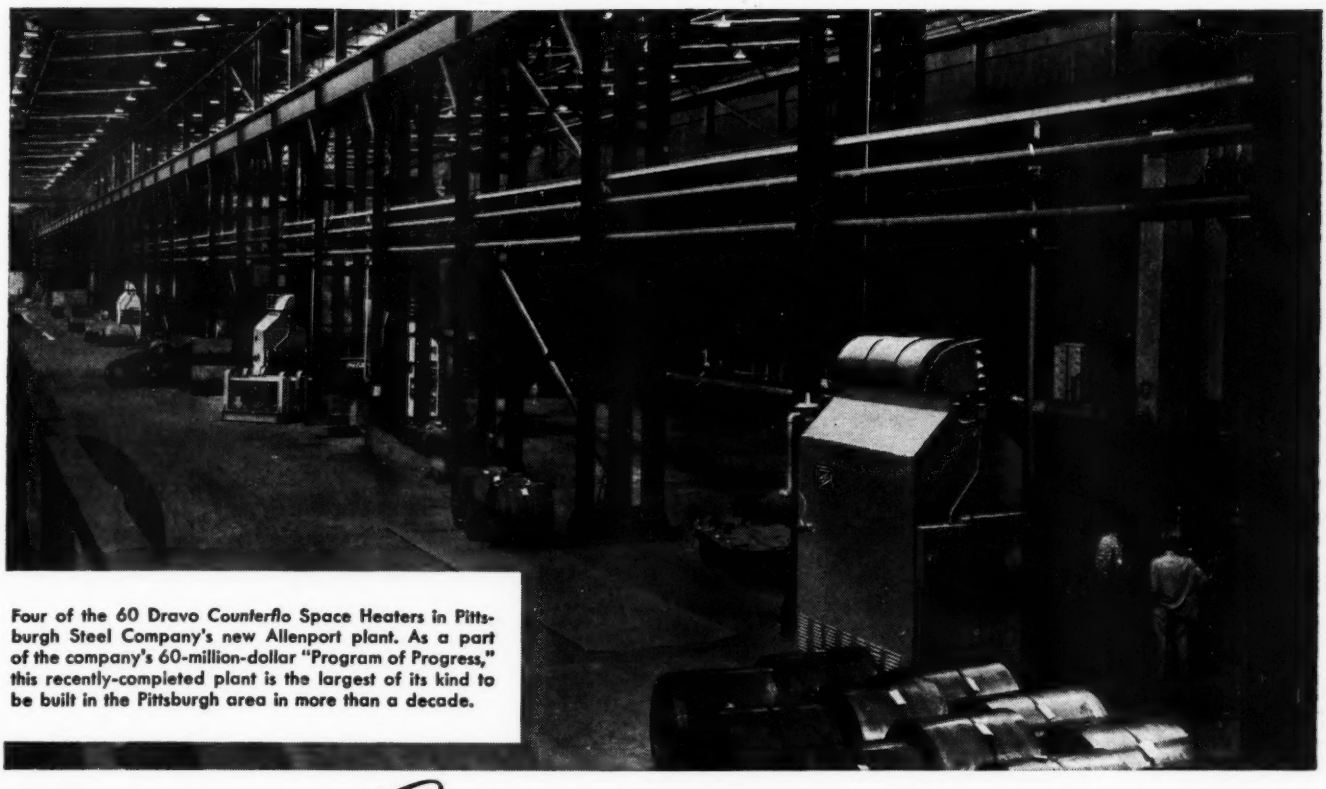
★ Winner of the 1953 "Engineer of the Year" title, awarded by the Indiana Society of Professional Engineers, is Paul Thomas, assistant general superindendent of the Gary Steel Works of United States Steel Corporation.

★ Tom Lyon, until recently director of the Domestic Expansion Division of the Defense Materials Procurement Agency, has joined Southwestern Engineering Company in the capacity of consulting engineer.

★ Merritt A. Hyde, advisory engineer for the mining, petroleum, and chemical section of Westinghouse Electric's industry engineering department, has received the company's highest award—the Westinghouse Order of Merit. L. A. Kilgore is appointed staff engineering manager for the company's East Pittsburgh Divisions; Maynard B.



ASCE CONVENTION
Civil engineers of the U. S. and Canada are shown discussing mutual problems at the recent New York convention of the American Society of Civil Engineers. Left to right are: Col. William N. Carey, exec. sec'y, and Walter L. Huber, outgoing pres. of the ASCE; Ross Dobbin, pres. and L. Austin Wright gen. sec'y. of the Engineering Institute of Canada.



Four of the 60 Dravo *Counterflo* Space Heaters in Pittsburgh Steel Company's new Allenport plant. As a part of the company's 60-million-dollar "Program of Progress," this recently-completed plant is the largest of its kind to be built in the Pittsburgh area in more than a decade.

60 DRAVO *Counterflo* SPACE HEATERS INSTALLED AT PITTSBURGH STEEL'S NEW ALLENPORT PLANT

To provide comfort heat in winter and ventilation in summer Pittsburgh Steel Company has installed 60 Dravo *Counterflo* Space Heaters at its new hot strip and cold rolled mills in Allenport, Pennsylvania. The positioning of these heating units in large steel-processing areas within the plant assures "uniform heat" when and where it is needed without distribution loss or costly steam piping installations.

Pittsburgh Steel chose Dravo *Counterflo* Heaters for three reasons:

FUEL ECONOMY. Heat is generated only where and when it is needed; no long warm-up period is required. Heat is transferred quickly and efficiently through the floating stainless steel combustion chamber to the circulating air. Dravo *Counterflo* Heaters operate at better than 80% efficiency.

EFFICIENT AIR DISTRIBUTION. Because of maximum air-throw it was possible to install the Dravo *Counterflo* Heaters in out-of-the-way places along the building column line. Final positioning of the adjustable outlet nozzles on each heater assures uniform distribution of heat throughout the area served. Heater fans provide good ventilation during hot summer months.

MINIMUM OF MAINTENANCE. With few working parts, Dravo *Counterflo* Heaters require a negligible amount of maintenance. The 60 heaters work automatically; no full-time attendent is required. Each heater has a combination burner that uses either gas or oil for fuel.

These are just a few of the advantages that Dravo *Counterflo* Space Heaters can offer you. Write today for more information. Use the coupon.

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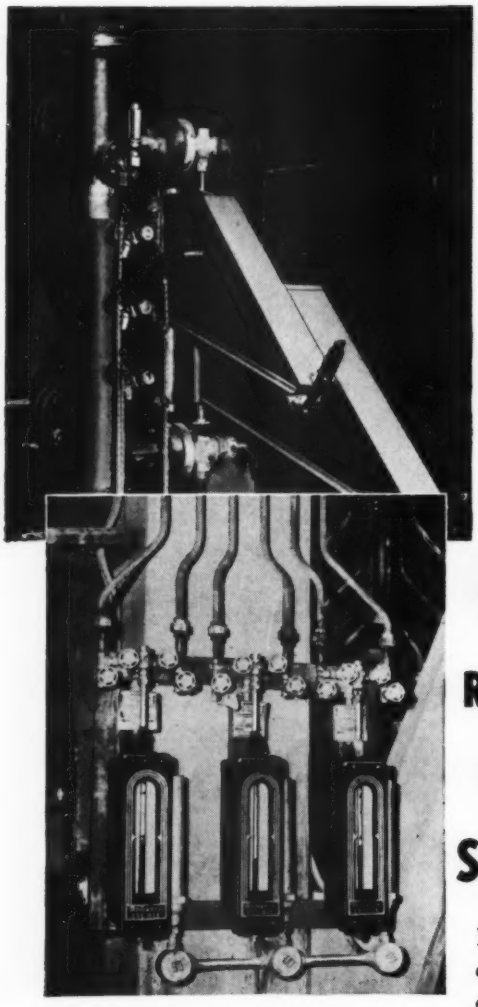

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MEN

—Starts on page 64

Wyman is named engineering and service department manager, and H. C. Coleman, assistant manager of the Apparatus Division.

★ Principals in the ceremony marking the start up of Unit Three in the Highgrove Steam Electric Plant of the California Electric Power Co.

are, left to right: Albert Cage, president, and Carl C. Ernst, vice president and general manager of the company; Lawrence C. Phipps; Don W. Darnell, chairman of the board of The Fluor Corporation, Ltd., designers and constructors of the project; and A. B. West, former Calelectric president and now a member of the board of directors. Ex-Senator Phipps, who helped finance the start of Calelectric almost 50 years ago, opened the valve to place the unit in operation.

★ Frederick S. Mallette, executive secretary of the Committee on Air Pollution Controls and staff member of the American Society of Mechanical Engineers, has been invited to give a Clayton Lecture on air pollution before the Institution of Mechanical Engineers of Great Britain in London on April 23, 1954.

★ Establishment by Barium Steel Corp. of three graduate fellowships for advanced studies in engineering is announced by J. A. Sisto, chairman of the board. Grants for one year will be made annually to Massachusetts Institute of Technology in mechanical engineering, the University of Pennsylvania in metallurgy, and Case Institute of Technology in electrical engineering.

★ Appointment of C. H. Nichols as head of the chemical engineering process design division of Engineering Corporation of America is announced. The division offers consulting engineering services to chemical and industrial plants.

★ Seelye Stevenson Value & Knecht announces that Stephen D. Teetor has been appointed associate in charge of foundations, soil mechanics, inspection and research.

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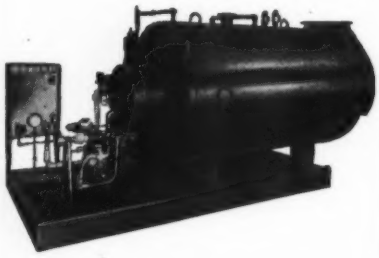

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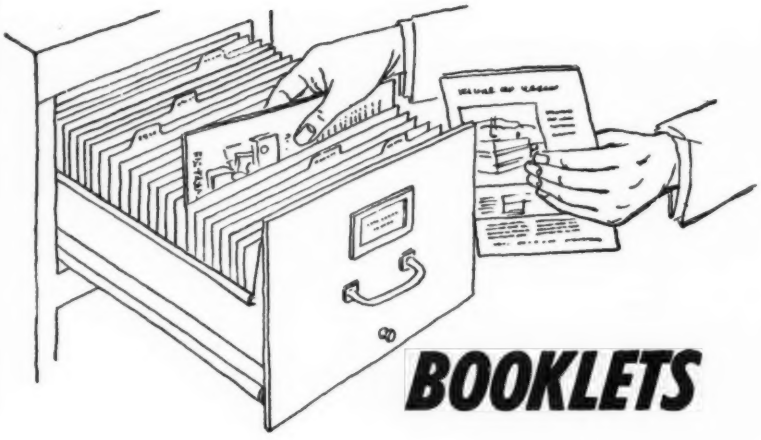


BOOKLETS

COMBUSTION CONTROL — A packaged, metered control unit designed to keep pace with the development of the larger sizes of pressure fired water-tube factory-assembled boilers is described in four-page bulletin c-101. Included are other units necessary for automatic combustion control. *Reliance Instrument Mfg. Corp., 190 Glen Cove Ave., Glen Cove, L. I., N. Y.*

DESLAGGERS — Air and electric drive wall deslaggers designed with the maintenance man in mind are described in four-page bulletin 1016. Sketches and cut-away views show the easy accessibility for inspection and maintenance and the simple steps needed to dismantle the units. *Copes-Vulcan Division, Continental Foundry & Machine Co., Erie 4, Pa.*

A BOILER BASE which features unobstructed waterleg visibility, positive boiler leveling, swift job-site assembly, and steel construction is described in six-page folder 62. A cut-away drawing shows each component of this Inspecto base with Leveleg supports. *Plibrico Co., 1800 N. Kingsbury St., Chicago 14.*

WELDING PAD GAGES built to be welded directly onto a tank or other liquid-containing structure, described in data sheet 205 are the answer to installations where there is solid matter in the vessel or where the thermal error of a gage glass would be high. Cross-sectional drawings show the design of both the reflex and circular type gage. *Jerguson Gage & Valve Co., 80 Fellsway, Somerville 45, Mass.*

METAL CLEANING—Illustrated by appropriate graphs and diagrams, a 4-page technical folder describes in detail the principles and methods used in the application of ultrasonic energy for the cleaning of metal parts. The Soniclean Process is described as a combination of the solvent degreasing cycle and the application of ultrasonic energy to produce precision metal cleaning. *Detrex Corp., Detroit 32, Mich.*

"METAL AT WORK," — Said to be one of the most ambitious projects undertaken by a multiplant corporation, this 87-page full color brochure is a comprehensive study of the products and production methods of the seven divisions of this company. This book is a basic primer in metalworking processes for steel boats, wire screen, alloys, tool steels, process equipment, pipelines, snowplows, and wire and cable. *Continental Copper & Steel Industries, Inc., 345 Madison Ave., New York 17.*

DRAFTING — The main feature of this brochure is a technical treatise on the subject of three dimensional drafting or axonometric drawing.

Personal copies of booklets can be obtained by writing directly to the manufacturers

Also included are descriptions of a number of the most widely used templates and stencils along with illustrations of Instrumaster implements used for this type of drawing. *John R. Cassell Company, Inc., 110 West 42nd St., New York 36.*

TYPE TS-21 DIESEL ENGINES, ranging in size from 2550 hp, 1800 kw to 6150 hp, 4400 kw, described in 7-page bulletin 224A, are most widely used in municipal power plants, central stations, and industrial power plants. Typical installation photographs illustrate these types of applications. Of special interest to all stationary power users is the cross-sectional drawing through the power cylinder showing the special features and improvements in design in the engine which are said to effect lower fuel and maintenance costs and longer life. *Nordberg Mfg. Co., Milwaukee 1, Wis.*

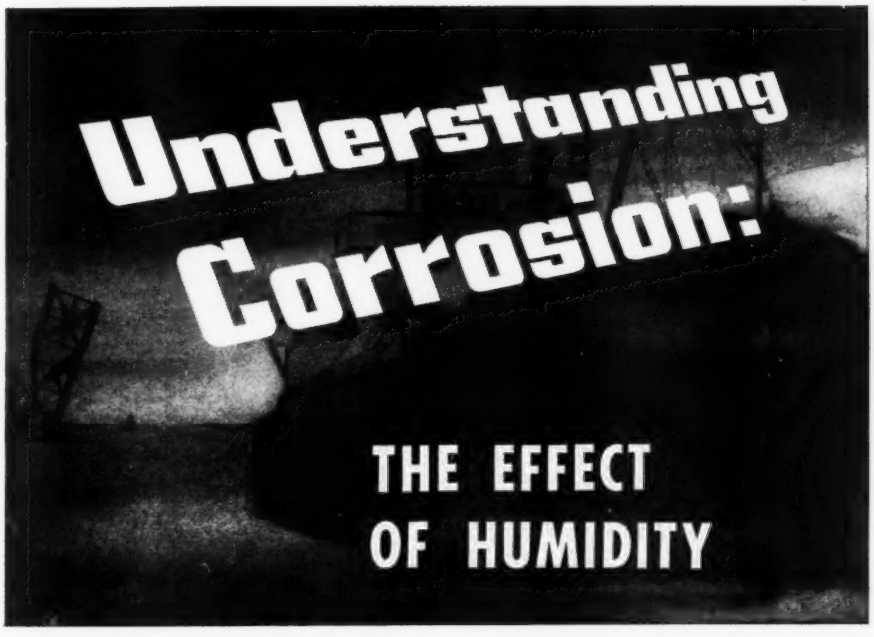
"THE ABC of Large A-C Motor Controls," is a 36-page special issue of the *E-M Synchronizer, No. 39*, presenting in an easily understood manner basic facts helpful in the proper selection and application of controls for large industrial motors. Illustrations and charts are explained and discussed in the latest developments in motor and personnel protective features. *Electric Machinery Manufacturing Co., Minneapolis 13, Minn.*

MOTORS—Three picture-story bulletins, GEA-6012, 6013, and 6027, contain complete descriptions of maintenance, performance, and protective features of Tri-Clad "55" motors. Each booklet includes a double-spread cutaway drawing of the motor. The three types discussed are the dripproof, inclosed, and gear motors. *General Electric Co., Schenectady 5, N. Y.*

COMPLEX PLANE ANALYZER, Type 250-A, a computer for network analysis and control system design, is described in a 6-page booklet. A detailed description of the instrument's theory and operation is included, along with lists of specifications and features. *Technology Instrument Corp., Main St., Acton, Mass.*

ELECTRONIC CONTROLS for heating, ventilating, and air conditioning are discussed in 7-page bulletin F6166. Flexibility is stressed and a complete description is given of the various elements required for system application. *Barber Colman Co., Rockford, Ill.*

CONTROLLER — 8-page bulletin P-811 covers the 077 Electronic Temperature Controller, with range now extended to cover -100 to 600 F. It also contains complete specifications, prices, and application information



Relative humidity — the degree to which air is saturated with moisture — influences corrosion in one direction where metal is exposed to atmosphere and in another where it is immersed in a solution surface-exposed to the same atmosphere.

It is humidity, in combination with temperature, that determines whether moisture can exist on a metal surface. Because moisture is essential to atmospheric corrosion, humidity, at normal temperatures, becomes the factor that determines whether corrosion will occur and to what extent. Its effect, negligible below 30%, increases until a critical point is reached at about 65%. When air so moisture-laden carries even minute quantities of such gases as sulphur dioxide, corrosive action is greatly intensified. It is this condition that renders difficult the protection of steel stacks, breechings and economizers in service below the dew point.

For metal immersed in a corrosive solution, the reverse is true. More rather than less humidity in the air above is the preferable situation because of the way in which humidity influences the rate of oxygen solution. The rapid evaporation that occurs in dry atmosphere leaves a cool, dense surface layer of liquid that carries dissolved oxygen through the solution as fresh, unsaturated liquid replaces it for a repetition of the process. As the pace at which oxygen is brought in contact with the metal is thus stepped up, corrosion increases proportionately.

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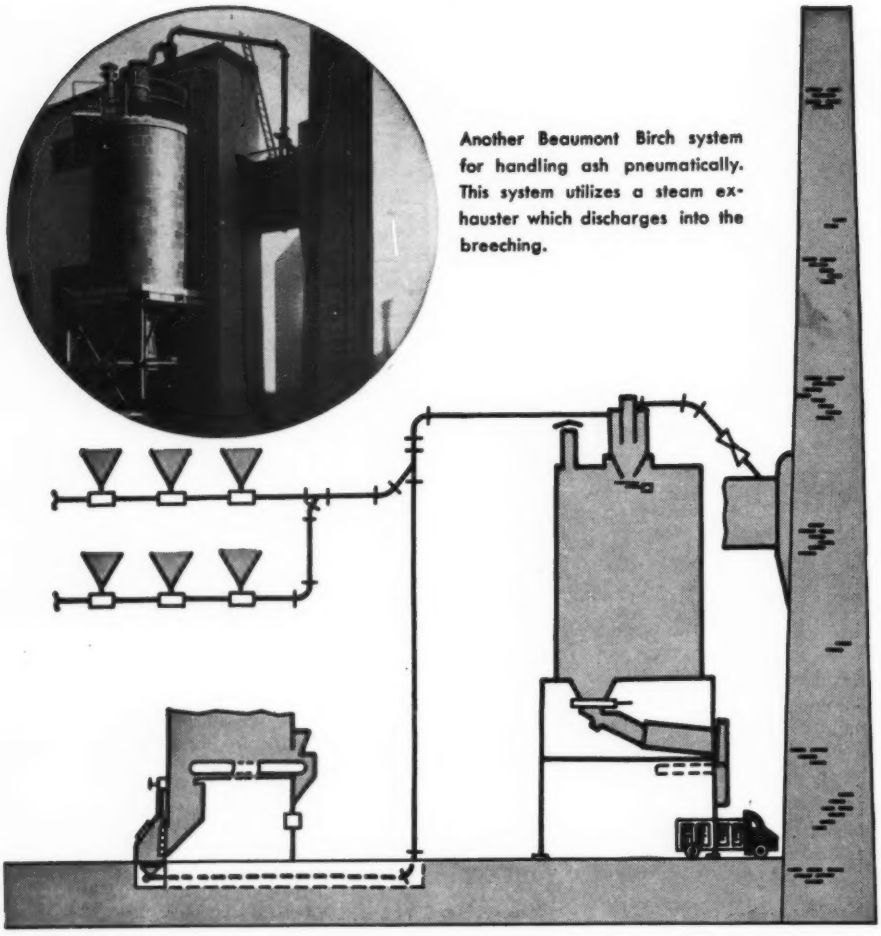

Another Beaumont Birch system for handling ash pneumatically. This system utilizes a steam exhauster which discharges into the breeching.

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The pneumatic ash handling system shown above is only one of the many bulk material handling systems in Beaumont Birch's complete line.

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BOOKLETS —*Starts on page 68*

on both the single-point and the cascade model, as well as data on resistance thermometer elements and wells, and Modutrol motors and industrial control motors suitable for use with the 077. *Minneapolis-Honeywell Regulator Co., Wayne and Windrim Ave., Station 64, Philadelphia 44, Penn.*

PUMPS — Technical paper 57 deals with the design and operation of controlled volume chemical feed pumps from basic units to specialized models. Complete systems are illustrated to show the application of these pumps in pH control, automatic titration, and proportional feeding. Included is a discussion of the Constametric, a reciprocating plunger, positive displacement type pump. *Milton Roy Company, Station H, 1300 E. Mermaid Lane, Philadelphia 18, Pa.*

VENTURI-TYPE METERS—16-page bulletin 500 contains data on operation, construction, accuracy, primary devices, and other general information of interest to power, process, and sanitation engineers who deal with fluid flow problems. The type MO meter and its component parts are illustrated by cross-sectional drawings. A full page capacity table is included. *Simplex Valve and Meter Co., Philadelphia 42, Penn.*

PIPE INSULATION—What you wou'd like to know about Kaylo heat insulation — physical characteristics, possible applications, K factors, standard sizes, thicknesses and forms, recommended thicknesses, and insulation efficiencies — is covered in an 8-page bulletin. The story of pipe insulation and heat insulating blocks is told by means of photographs, graphs, and charts. *Owens-Corning Fiberglas Corp., Toledo 1.*

V-BELT DRIVES—Compiled primarily for engineers, this 52-page manual presents in a simple, clear manner all elements of V-belt drives. Complete with tables, graphs, and diagrams, it includes the new V-belt industry numbering system and the numbering system of major manufacturers in the field. *Boston Woven Hose & Rubber Co., Dept 609-26, P. O. Box 1071, Boston 3, Mass.*

THIS FRESSURE LOSS calculator for steam valves is a handy, pocket size cardboard chart which does your figuring for you. Complete instructions are printed on the calculator. *Golden Anderson, 1232 Ridge Ave., Pittsburgh 33, Pa.*

consulting engineers' calendar

Date	Sponsor	Event	Location
Jan. 18-22	American Institute of Electrical Engineers	Winter Meeting	Statler Hotel New York, N. Y.
Jan. 25-27	American Society of Heating and Ventilating Engineers	60th Annual Meeting	Rice Hotel Houston, Texas
Jan. 25-28	Plant Maintenance & Engineering Show	Exposition	Conrad Hilton Hotel Chicago, Ill.
March 9-12	American Management Association	General Management Conference	Fairmont Hotel San Francisco
March 10-12	American Society of Mechanical Engineers	International Meeting	Del Prado Hotel Mexico, D. F.
March 15-19	National Association of Corrosion Engineers	10th Annual Conferences	Muehlebach Hotel Kansas City, Mo.
April 1-3	Electrical Maintenance Engineers Assoc. of Southern Calif.	7th Electrical Industry Show	Shrine Hall Los Angeles
April 15-19	American Institute of Electrical Engineers	Southern Textile Conference	Georgia Tech. Atlanta, Ga.
April 26-30	American Society of Tool Engineers	Industrial Exposition	Convention Center Philadelphia, Pa.
April 27	Association of Consulting Chemist and Chemical Engineers	Symposium-Banquet	Hotel Belmont Plaza New York, N. Y.
May 4-7	American Welding Society	Spring Meeting	Hotel Statler Buffalo, N. Y.
May 5-7	Hydraulic Institute	Spring Meeting	Skytop Lodge Skytop, Pa.
May 10-12	Compressed Air and Gas Institute	Spring Meeting	The Homestead Hot Springs, Va.
May 17-20	Basic Materials Exposition and Conference	2nd Annual Exposition	Amphitheater Chicago, Ill.
May 23-28	American Water Works Association	National Convention	Seattle, Wash.
May 24-27	University of Michigan	Instrumentation and Industrial Hygiene	Rockham Bldg. Ann Arbor, Mich.
July 13-15	Western Plant Maintenance Show	Conference and Exposition	Pan Pacific Bldg. Los Angeles, Calif.

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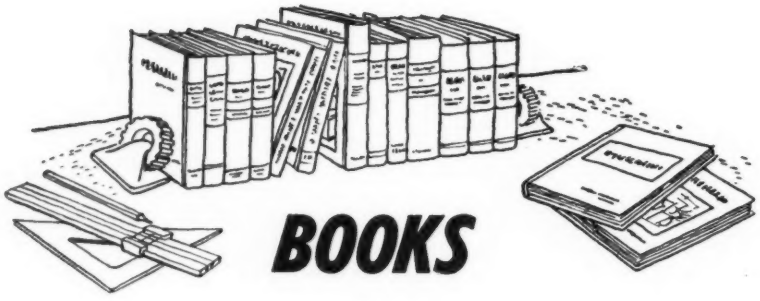

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ELEMENTS OF ELECTRICITY, Fourth Edition, by William H. Timbie and Alexander Kusko, John Wiley and Sons, Inc., 631 pages, $5.50.

Reviewed by E. R. Whitehead, Director Department of Electrical Engineering Illinois Institute of Technology

Elements of Electricity has long enjoyed favor as an elementary textbook adapted to the needs of the electrician or technician. The authors have successfully kept this limitation in mind throughout, with the result that the book will be both interesting and useful to those for whom it is intended.

Especially noteworthy features of this text are the careful matching of the problems to the illustrative examples on all topics which are quantitatively treated, and the excellent, concise chapter summaries. The care given these matters will be reflected in greater success on the part of the serious student who takes the trouble to do the problems and test his progress with the aid of the summaries.

Beginning with a discussion of Ohm's Law, the authors deal successively with electrical power, energy, conductors and resistance, magnetic circuits, and electric machines. The next chapter brings the reader up to date on batteries and electrochemical action in an interesting and effective manner. Circuit elements and circuit simplification are developed to prepare the reader for a long chapter on alternating currents. A great deal of effort has been expended to bring this subject within the range of elementary trigonometry, at least with respect to formal practical calculations.

The chapter on electronics and electron tubes serves more to whet the appetite than to instruct because of the sheer magnitude of the task. The book closes with a chapter on electrostatic behavior which, while important, somehow seems to dangle as an afterthought.

Professional engineers will find *Elements of Electricity* a useful addition to their libraries if their field of specialization is other than electrical engineering, and electrical engineers may well recommend it to their non-professional colleagues.

PRINCIPLES OF TRANSISTOR CIRCUITS, edited by Richard F. Shea, John Wiley & Sons, Inc., New York, 535 pages, $11.00, 1953.

Reviewed by Reinald S. Nielsen Cook Research Laboratories

A bridge between the mathematical and physical theory of transistors, and their practical application is provided by this volume. Editor Shea and his co-authors make the first unified attempt at filling the gap between the theoretical discussion of Shockley's *Electrons and Holes in Semiconductors* and the often incomplete discussions of practical transistor applications appearing in current literature.

The twenty-two chapters plus three appendices of the work are roughly organized to present: (1) low frequency principles and applications of transitors, (2) high frequency principles and applications, (3) analytical techniques of measurement and mathematics useful in describing the transistor as a circuit element, and (4) a review of semi-conductor devices related to the conventional three-terminal transitor.

The book covers the present engi-

neering application of transistors quite completely while deriving the analytical techniques which will serve future application. Appendix II, "Definition of Terms," will help to unify semi-conductor nomenclature and promote easier understanding for those engineers first looking at semi-conductors. Mathematical sophistication has been held to a minimum so that the engineer who is rusty on his technique can still find value in the book. On the whole, the book is well organized and explicit. *Principles of Transistor Circuits* should become and remain a useful reference to the newcomer and "old hand" in the semiconductor field.

SEWERAGE AND SEWAGE TREATMENT, by Harold E. Babbitt, Seventh Edition, 1953; John Wiley & Sons, Inc., 674 pages, $8.00.

Reviewed by C. W. Thompson
Plant Superintendent
Benton Harbor-St.Joseph, Michigan
Sewage Treatment Plant

The preparation of standards of design in the sewerage field by accepted authorities such as state boards of health, the Upper Mississippi River Board of Public Health Engineers, and the Great Lakes Board of Public Health Engineers have required extensive changes in the literature. These changes are incorporated in this edition.

This book contains new information on reinforced concrete sewer design, arch analysis, stresses in flexible rings, new dimensions of vitrified clay pipe, and information on use of aluminum manhole appurtenances.

This edition contains a new section on internal combustion engines together with a discussion of dual fuel engines. There are also new sections pertaining to design of bar screens and hygienic aspects of sludge utilization.

Under sewage treatment this book has new information on preaeration of sewage, a section on detergents, capacity of digestion tanks, filter loadings, control of foaming, and disposal of radioactive materials. New processes of sewage treatment, such as Hays, Kraus, Okun, and Fair are discussed.

The chapter on industrial wastes is rewritten and expanded to include new methods of treatment.

This book is well suited for sanitary engineers having to do with sewerage or industrial wastes either in the field of design or operation.

ALSO AVAILABLE

DIRECTORY OF PUBLIC OFFICIALS OF THE MIDWESTERN STATES, Midwest Conference Building Officials and Inspectors, 68 pages, $10.00. This directory gives the names of public officials in Midwestern states to administer and enforce codes and regulations governing building construction. It also lists the types of codes under which the governmental agency regulates building, plumbing, electrical, heating, and related subjects.

STANDARDS ON CAST IRON PIPE AND FITTINGS may be obtained from the American Standards Association, 70 East 45 Street, New York 17, N. Y. at the following prices: Cast Iron Pit Cast Pipe for Water or Other Liquids (Revision of A21.2-1939), A21.2-1953. $.45

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Short Body Cast-Iron Fittings, 3 inch to 12 inch, for 250-psi, Water Pressure Plus Water Hammer, A21.10-1952. $.35.

A Mechanical Joint for Cast-Iron Pressure Pipe and Fittings, A21.11-1953. $.35.

MATERIALS FOR PRODUCT DEVELOPMENT—1953, Clapp & Poliak, Inc., 265 pages, $7.50. This is the text of the discussions at the first basic materials conference held in New York, last June. It contains discussions of the many modern materials now available for the production of a variety of goods. The conference was the first of its kind and was attended by executives who are concerned with the design, engineering, and development of all types of consumer and industrial products. Eighteen papers are included. They are illustrated by 36 tables and 30 graphs. The volume also includes a text of 83 questions and answers offered at the conference.

INDUSTRIAL FILMS

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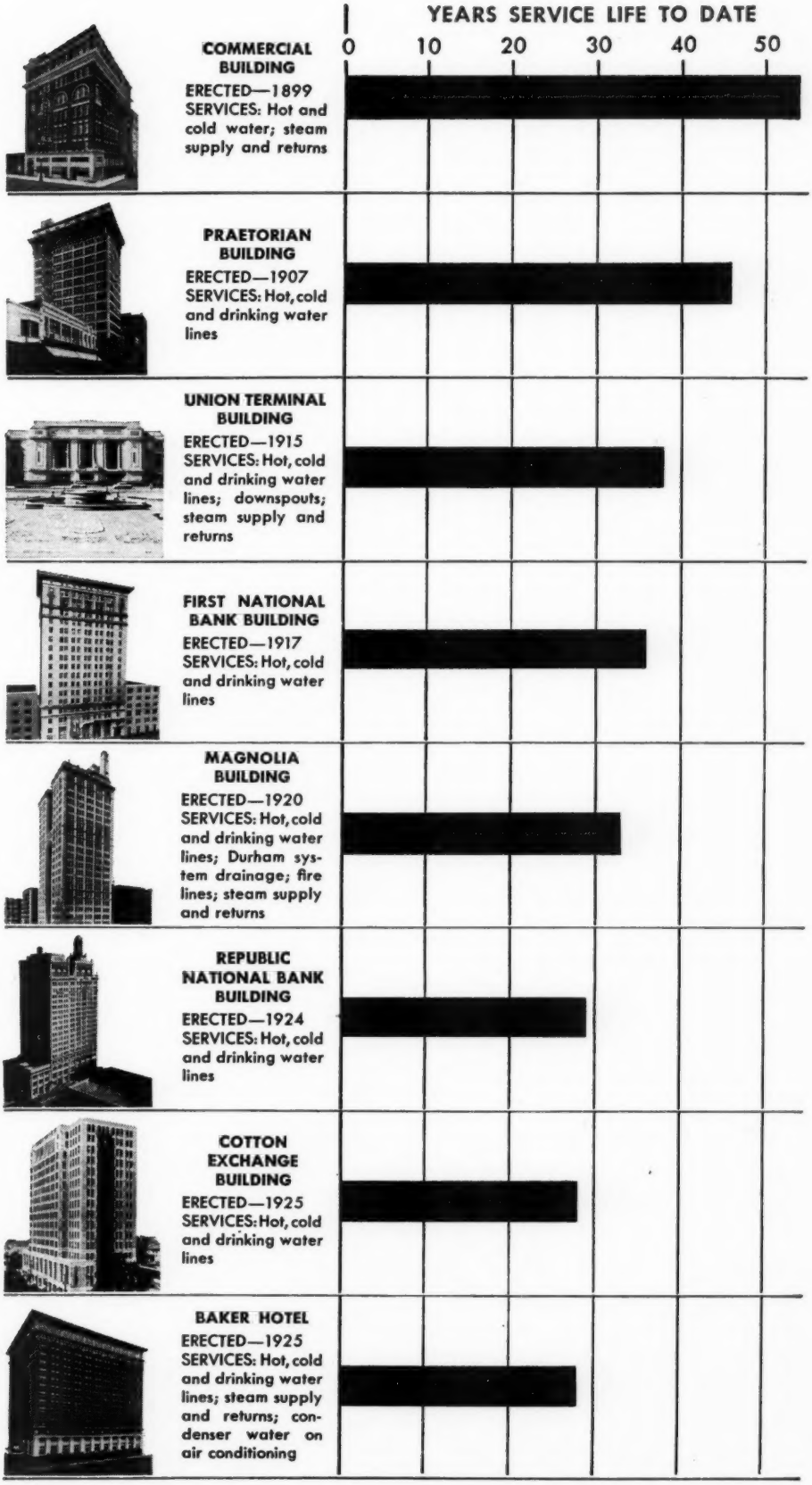

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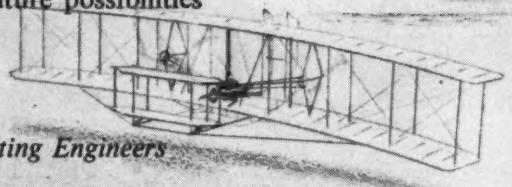

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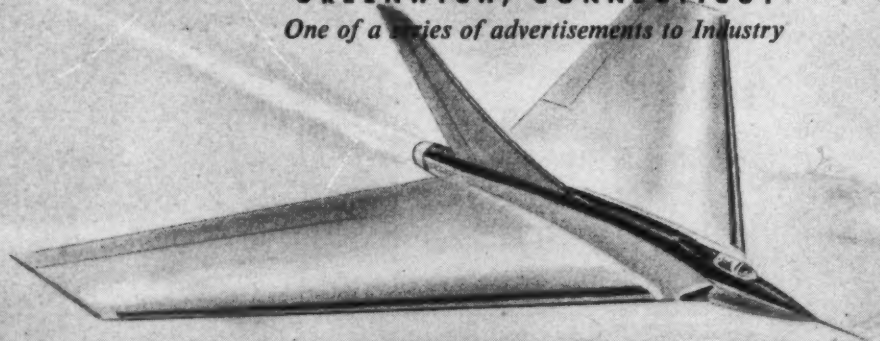

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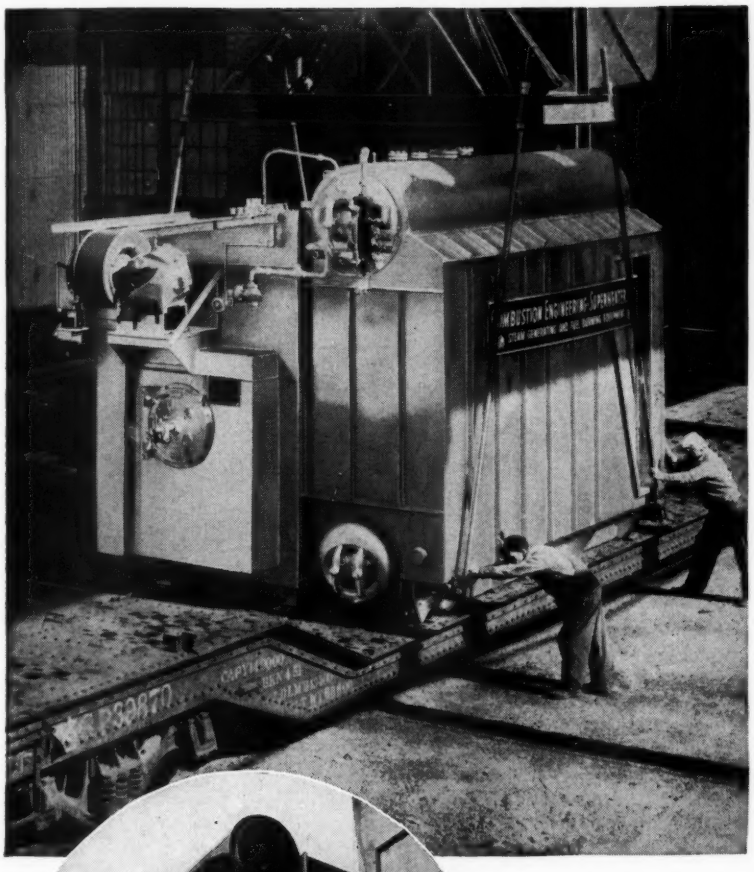

...the Package Boiler with EXTRA features

If you're in the market for a Package Boiler, here's the problem you face. There are a number of water-tube package boilers being offered today. Most of them look pretty much alike. And, in some respects, they *are* alike.

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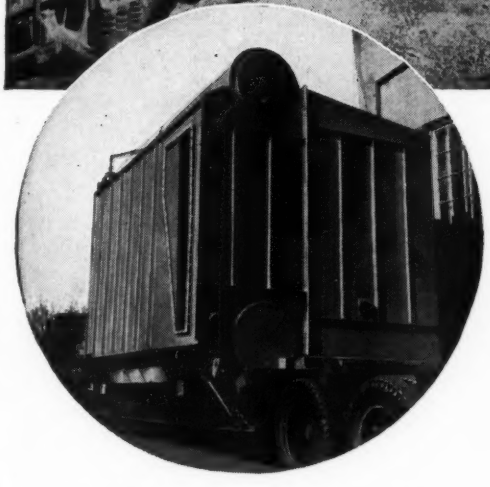

VP Boilers are available in capacities from 4,000 to 30,000 lb of steam per hr; pressures to 250 psi. Send for Bulletin VP-252

1. **Fully Water Cooled Furnace**—More cooling area per cubic foot of furnace volume than any other boiler of the VP's size and type. In all but the three smallest sizes, the VP Boiler has water-cooled walls on *all six sides* of the furnace—including the burner wall.

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B-673A

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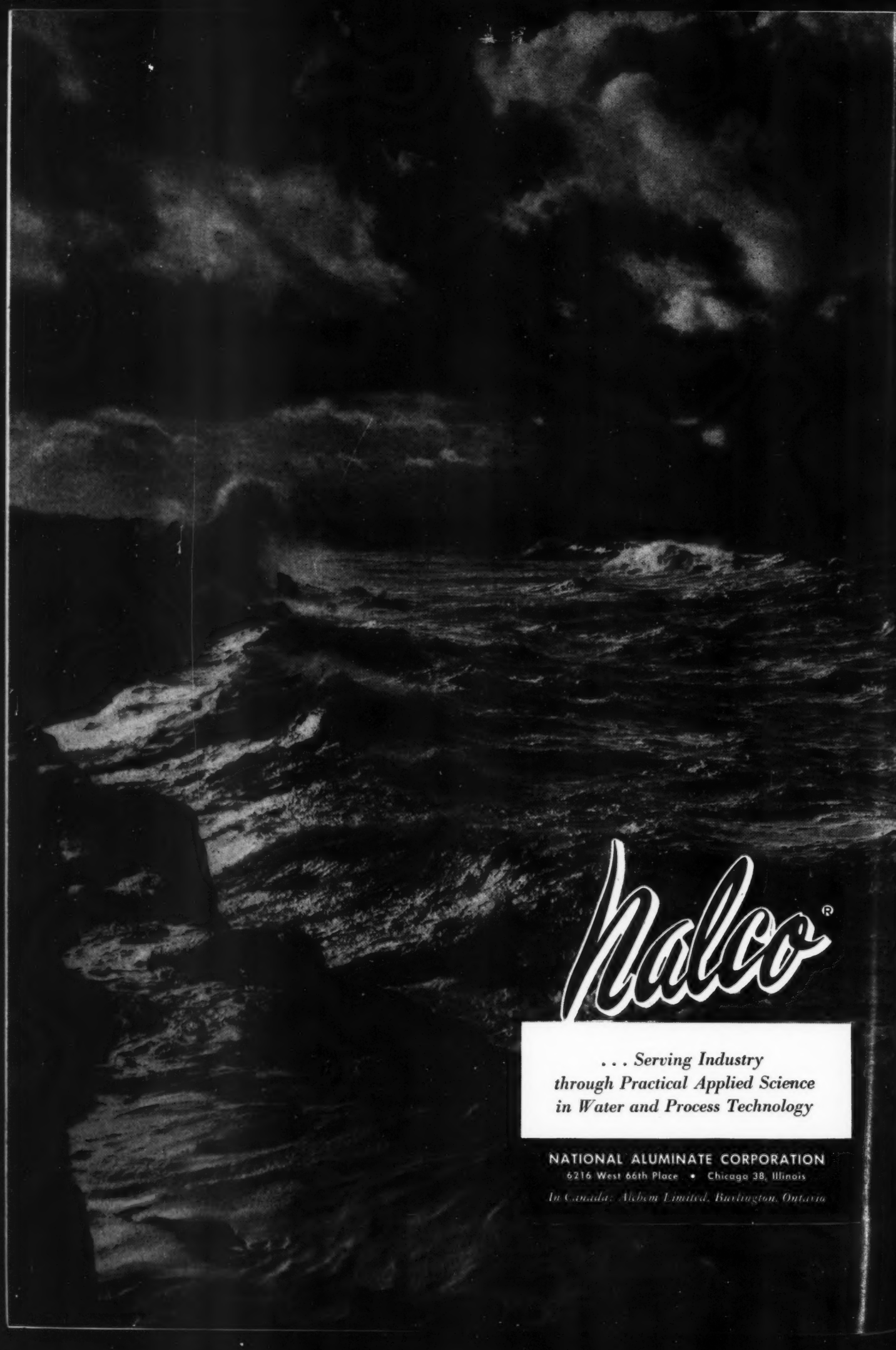
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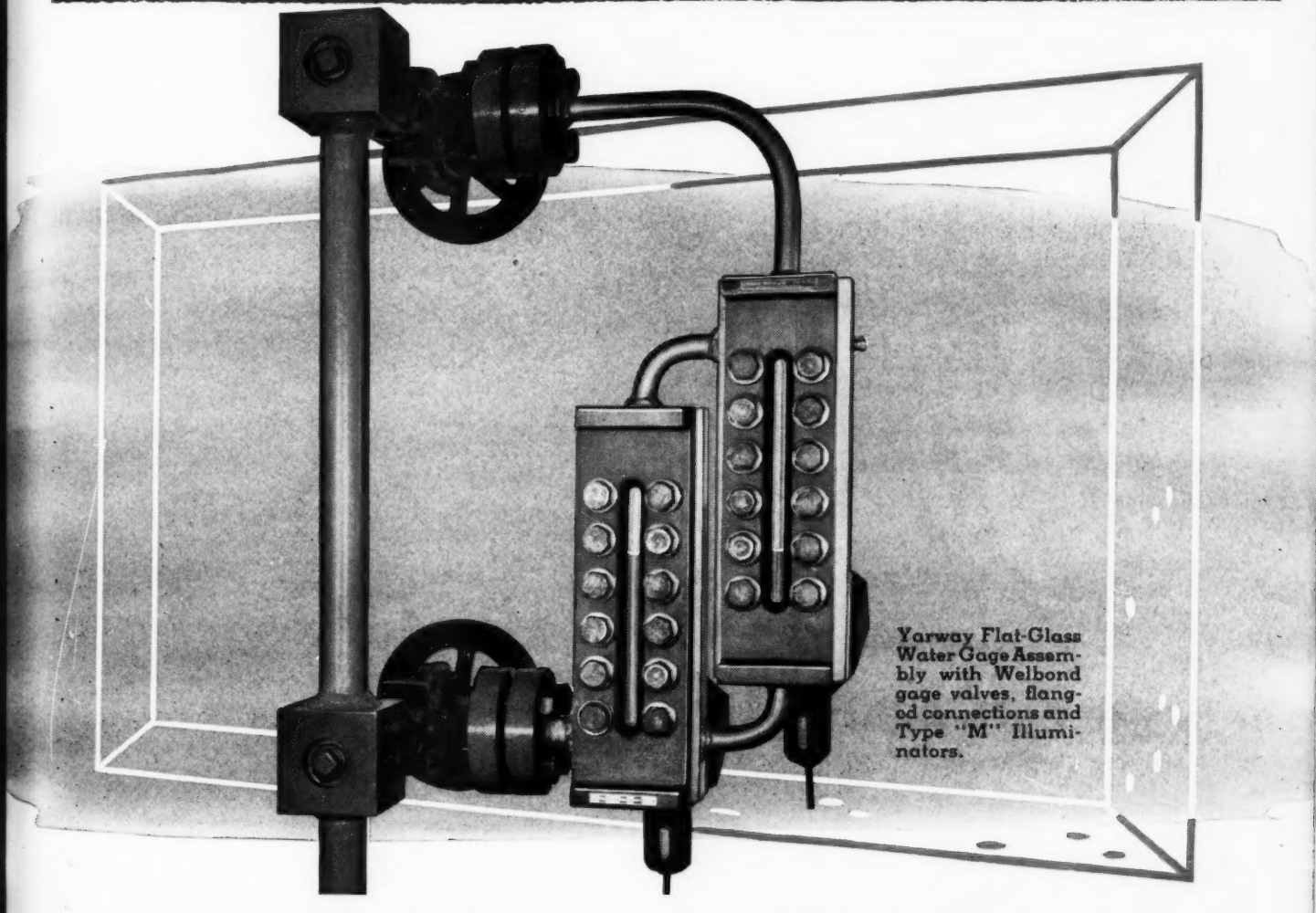

Yarway Flat-Glass Water Gage Assembly with Welbond gage valves, flanged connections and Type "M" Illuminators.

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This new Yarway water gage assembly has been developed to meet the demands for greater dependability, longer life, and more accurate readings in high pressure service.

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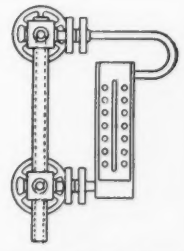
Yarway Type "M" Illuminators on the gage inserts cause the meniscus at water level to "shine like a star". This illuminator is especially effective in penetrating deposits on gage glass, dust particles in air and extraneous light.

For full information, write for Yarway Bulletin WG-1811.



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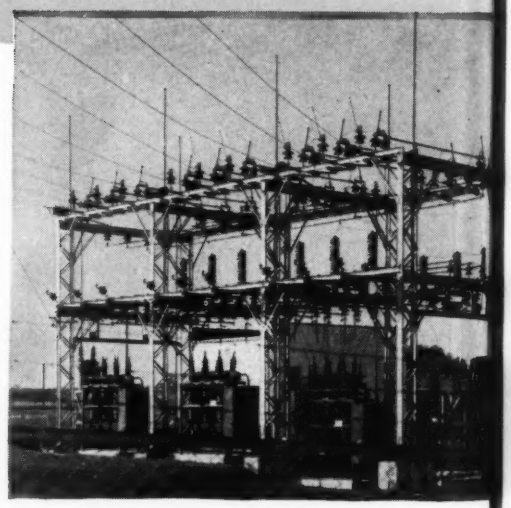

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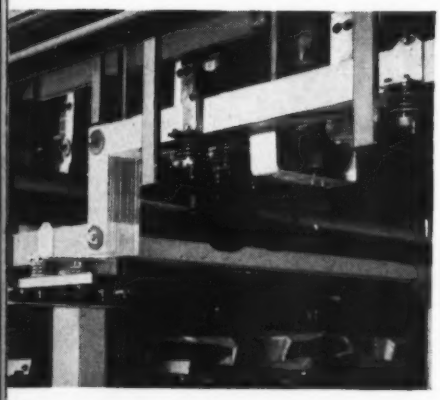

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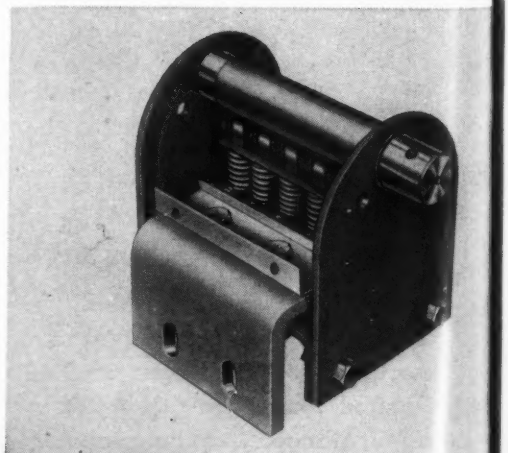
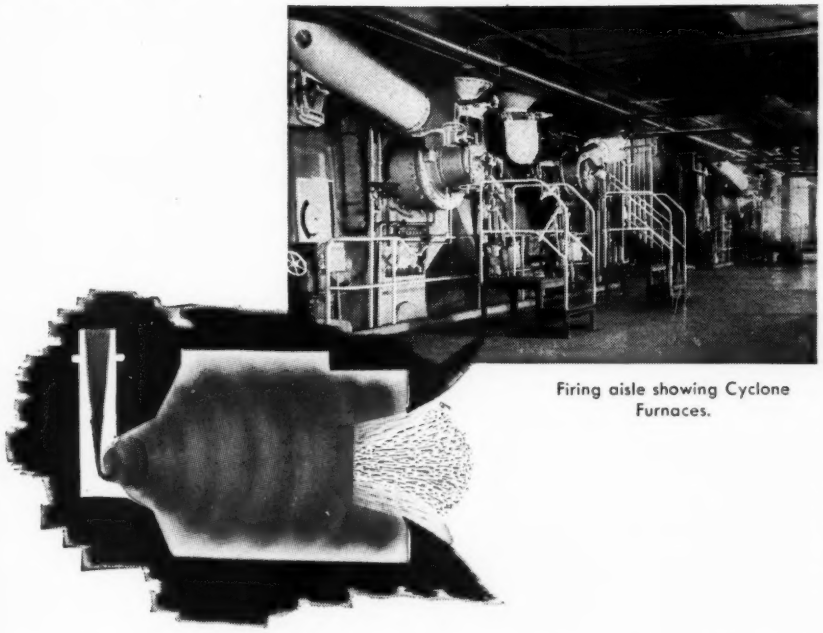
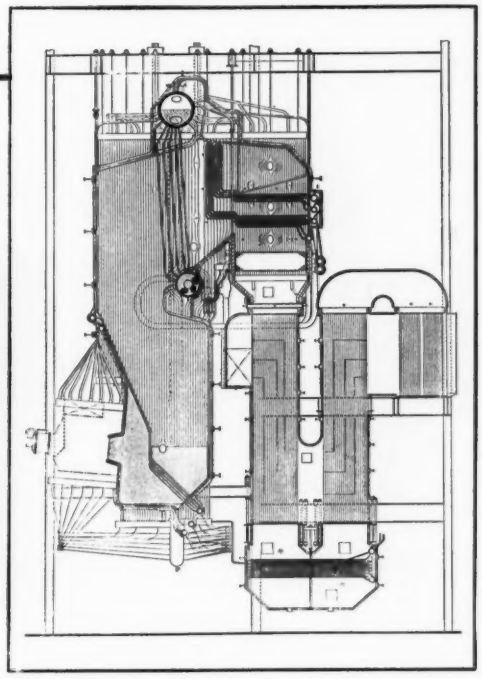


More B&W Pressurized Cyclone Furnace Boilers on the Line

LARGE CHEMICAL PLANT INSTALLS 4TH and 5TH CYCLONE UNITS



Firing aisle showing Cyclone Furnaces.



B&W Cyclone-Fired Radiant Boiler for a leading chemical manufacturer. Four units of this design are installed in one power plant. A similar unit is in operation at another of the company's plants. Each boiler normally generates 400,000 pounds of steam per hour with superheater outlet conditions of 1250 psi, 830 F. The design pressure is 1400 psi.

Having pioneered Cyclone Furnace firing for industrial steam plants, a large chemical manufacturer has recently placed its fourth and fifth Cyclone-fired boilers into operation. The first pressurized Cyclone-fired boiler ever built has been in successful continuous operation at one of this company's plants since February 1949.

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Low fly-ash discharge to the stack, without the use of precipitators, was a prime consideration in the original selection of Cyclone Furnaces for the first three units back in 1946. Most of the coal-ash is converted to liquid slag which is removed through the slag tank, and can be disposed of readily. Thus, some of the most difficult problems in power-plant operation — preventing heavy stack discharge and eliminating the handling of large amounts of useless fly ash—are overcome. But, in addition to solving these problems, a whole host of other benefits have also been realized, and Cyclone Furnaces were thus the logical choice for the firm's two new units.

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Simplification of the entire process of supplying and burning the coal is an important asset of Cyclone Furnace firing. It reduces maintenance costs, makes operation easier, and improves availability. This is because pulverizers, with their drives, fans, ducts, and burners are not needed, since the Cyclone Furnace uses coal which is merely crushed, instead of pulverized. This also increases safety and lends itself readily to "push-button" operation.

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Greater firing efficiency results from the great turbulence and high temperatures in the Cyclone Furnace. Carbon loss is practically eliminated. In addition, excess combustion air is reduced, bringing a corresponding reduction in heat lost to the stack.

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Pressure-firing without induced draft fans is another pioneering achievement of this chemical company in its five Cyclone-fired units. Since the first boiler was placed on the line nearly five years ago, pressure-firing has contributed to smoother operation with reduction in fuel consumption. Having only forced draft fans on the unit eases the operator's tasks, simplifies controls, and saves considerable auxiliary power.

B&W's experience with Cyclone Furnaces, Pressure Firing, and so many other cost-saving engineering advances, is at your disposal when your next plant is being designed.

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BOILER DIVISION

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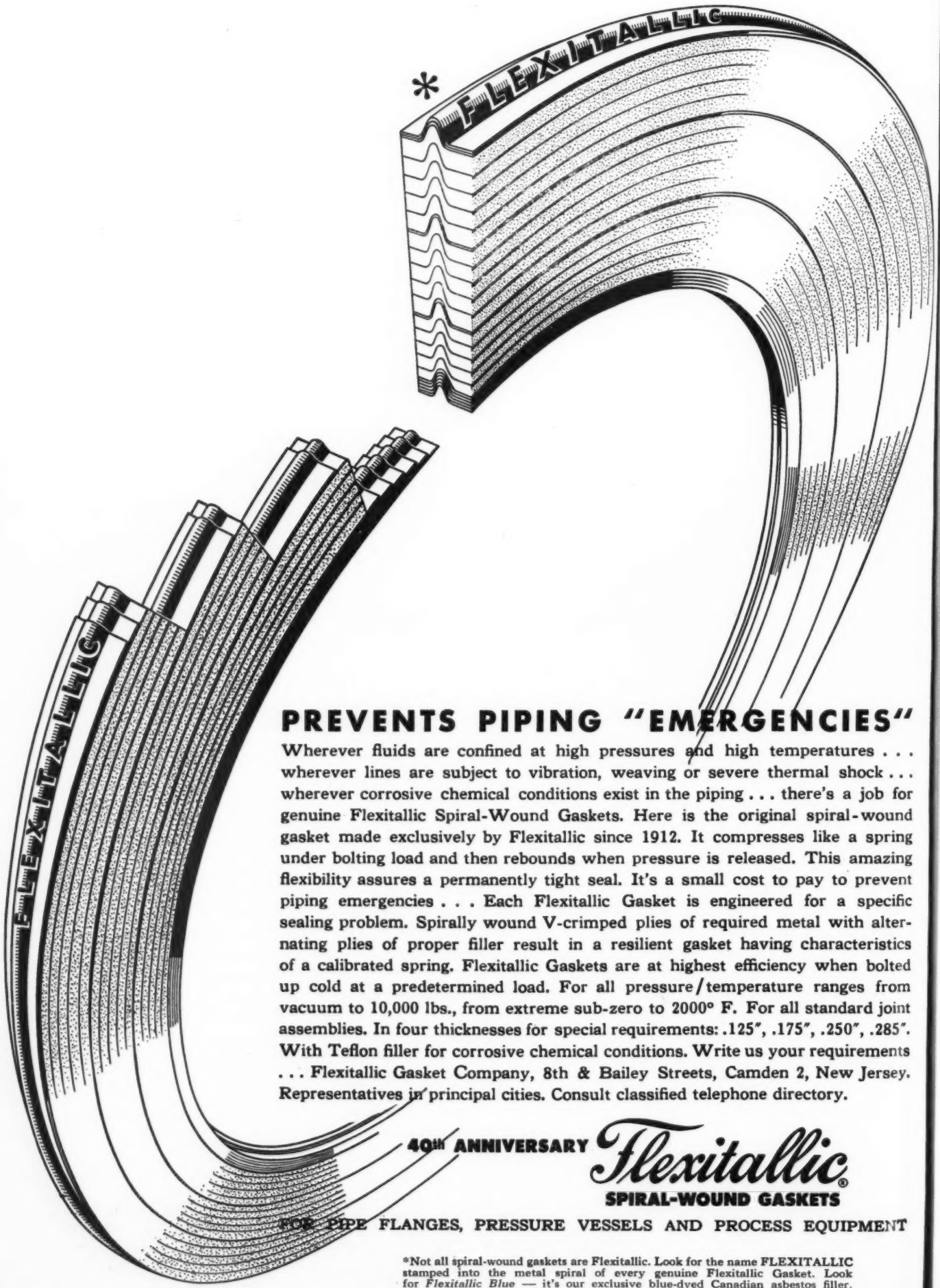

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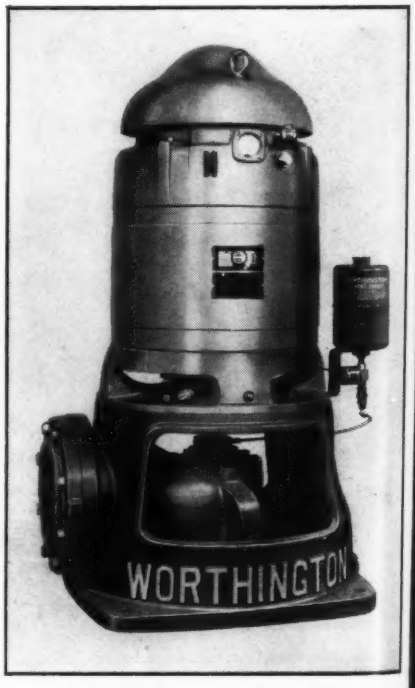

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